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SITKA BLACK-TAILED DEER:

Proceedings of a Conference in Juneau, Alaska

U.S. Department of Agriculture, Forest Service, Alaska Region, in cooperation with the State of Alaska, Department of Fish and Game

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SITKA BLACK-TAILED DEER: PROCEEDINGS OF A CONFERENC
and J.W. Schoen, Editors. U.S. Department of Agricu
Region (P.O. Box 1628, Juneau, Alaska, U.S.A. 99802
of Alaska, Department of Fish and Game. Series No. i

Foreward

Alaska's status as a sparsely populated, under-u
the continent is rapidly changing. Wildlife managers
denly confronted with the need to understand the pote
pressure to influence wildlife populations. The purp
help us meet our responsibility in the preservation a
black-tailed deer (*Odocoileus hemionus sitkensis*) and

While the conference was conceptualized as a forum through which we Alaskans could address our concerns, findings, and theories to an assemblage of persons with relevant experience and expertise, it was structured in that some of the local and visiting participants were asked to open the issues with prepared presentations and to submit papers paralleling those presentations for inclusions in printed proceedings. Some papers do not deal specifically with Sitka blacktails, but they were invited to provide background knowledge that the conference planners considered important. The proceedings unfortunately omit the productive and often provocative debate stimulated by the presentations, but they give the participants a reference base for pursuing the issues that arose. Further, these proceedings represent the first comprehensive technical publication devoted to the ecology of this subspecies and management problems associated with it.

The concept of the conference originated with William L. Sheridan of the Forest Service - Alaska Region's Division of Fisheries and Wildlife Management. Planning and arrangements were largely carried out by Ron Burraychak of the same office. The undersigned accepted the task of assembling manuscripts for the proceedings and communicating with authors to ensure that the minimal editing met their acceptance.

Information presented by some may be interpreted differently by others. But none of us has an unimpeachable claim to omniscience, so it is more useful for the findings and conclusions of each to be considered by the wider audience that will be involved in the ultimate fate of Sitka blacktails and the audience of professional specialists who may, and are eagerly invited to, share their knowledge with us.

Olof C. Wallmo
John W. Schoen

The conclusions and viewpoints published in this text do not necessarily reflect the views or policies of the U.S. Department of Agriculture, the State of Alaska, or the Province of British Columbia.

Contents

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Sitka Black-tailed Deer: Proceedings of a Conference in Juneau, Alaska+

Introduction

Opening of the Conference

The opening session of the conference was planned so that agency officials could explain the administrative setting in which the management of deer and their habitats is conducted in southeast Alaska. Agency programs were presented by John A. Sandor, Alaska Regional Forester, USDA Forest Service; Robert A. Rausch, Director, Division of Game, Alaska Department of Fish and Game; and Donald L. Schmiege, Program Leader, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service.

For the clarification of foreign and other readers, the administrative setting in southeast Alaska places authority under two agencies. The responsibility of preserving and managing wildlife habitats on National Forest System land is placed with the USDA Forest Service, Alaska Region, with research activities conducted largely by the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. And, the responsibility of managing wildlife populations is placed with the State of Alaska, Department of Fish and Game, Division of Game.

In this introductory section, D.E. McKnight reviews the background knowledge which guides the management of deer. W.L. Sheridan discusses the Forest Service program for managing wildlife habitat.

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*Held at Juneau, Alaska, U.S.A., on February 22-24, 1978, under the sponsorship of the State of Alaska, Department of Fish and Game, and the U.S. Department of Agriculture, Forest Service, Alaska Region.

*Edited by Olof C. Wallmo of the USDA Forest Service and John W. Schoen of the Alaska Department of Fish and Game.

The History of Deer Research in Alaska

by

Donald E. McKnight,
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Alaska Department of Fish and Game

Introduction

When I started reviewing information gathered on Sitka black-tailed deer in Alaska, it was evident that few formal research studies had been conducted on this subspecies or its habitat. Instead, the information base upon which it is now managed has been developed largely through trial-and-error application of techniques developed elsewhere. Our understanding of this animal would be poor indeed had it not been for the perseverance of a few astute, well-trained, dedicated individuals relying primarily upon their interpretation of personal observations and observations of laymen, weighted heavily with intuition.

To mention only those studies which would currently meet our collective standards for research would be to ignore the bulk of this information base. Consequently, I will treat briefly all information gathering activities dealing with deer and deer habitat which have occurred in Alaska since 1951 when formal biological studies of deer under the Federal Aid in Wildlife Restoration Act began. For convenience of presentation, I have segregated these investigations into three time periods --from 1951 to statehood (1960), from 1960 to 1970 (the first decade of State management), and from 1970 to the present (1977).

Research Conducted Prior to Statehood

Population studies--The first formally reported studies of deer populations were those of Sigurd Olson in 1951 [Nelson, 1951]. In his quarterly reports for that year, Olson reported several observations on fall movements of deer in relation to snow accumulations. The next year, Olson [Nelson, 1952] reported observations on fawning rates and spring movements from wintering areas. He also reported preliminary efforts to improve procedures for measuring harvests and hunting pressure through use of a hunter questionnaire administered in winter 1952. Already recognizing implications of winter-induced mortality, Olson conducted spring surveys to determine where winter deer mortality occurred in relation to the beach and found that winter-killed

carcasses were almost entirely restricted to the beach fringe. He also collected pelvises and skulls of winter-killed deer in an effort to develop a technique for distinguishing the sex of these deer on the basis of pelvic characteristics. Olson reported that sex of adults could be determined from the size and shape of the pelvis; the shape of the symphysis of the ishium distinguishes the sexes. Sex of fawns could not be distinguished using characteristics of the pelvic girdle alone, however. Olson established many of the winter mortality transects in 1952 which are still our major source of information on winter mortality.

In 1953, Olson intensified his efforts to gather and analyze data on hunter harvests. Using a questionnaire in southeastern Alaskan communities, he determined the magnitude of the harvest, analyzed distribution of hunting pressures, and computed hunter success ratios [Nelson, 1953]. Through contact with successful hunters, Olson gathered information correlating antler development with age of the animal and assessed the weight and physical condition of harvested animals. Magnitude and sex and age composition of winter mortalities were determined using the standardized transects established in 1952.

Efforts in 1954 were similar to those in 1953. But in January 1955, attempts were made to trap, mark, and release deer on Kupreanof Island [Nelson, 1955]. Five animals were captured that month. Winter mortality surveys were continued in 1955, as were harvest surveys. Also in 1955, Olson, in an initial attempt to census deer in Southeast, conducted winter beach counts from the air and from small skiffs.

David Klein, who had begun work for the U.S. Fish and Wildlife Service during 1954, reported trapping and ear-tagging 14 deer during winter 1955-56 [Nelson, 1956]. In 1956, Klein conducted composition counts from the time of fawning through fall in an attempt to document fawn losses. He also continued beach counts from the air and from skiffs.

In 1957, Klein selected and established what he termed "Representative Management Index Areas" for deer in Southeast. Essentially, this was a process of systematizing some of the previous surveys and incorporating new range surveys into a standard procedure for analyzing herd trends, harvests, and range quality. Klein used winter beach counts of live deer made from airplanes and boats, spring beach transect counts of winter-killed deer, and intensive surveys of hunter harvests to analyze herd condition. He also conducted studies of fawn/adult ratios during fall and winter to determine productivity of the herd and overwintering fawn survival [Klein, 1957]. To develop a technique for determining herd welfare and range conditions on the basis of harvested animals, Klein measured hunter-killed deer and found that there was a correlation between hind foot measurements and range conditions [Klein, 1957]. Klein's studies of harvests and winter mortality patterns continued through 1959, although he apparently ceased all tagging efforts and censuses of live deer.

Harvest studies in 1958 were intensified to provide insight into the chronological distribution of the deer harvest. Efforts that year also revealed that many bucks, at least in the northern parts of southeast Alaska, did not grow visible antlers until their third spring [Klein, 1958]. In fact, about a third of the "anterless" deer shot by Juneau hunters in 1958 were 1-1/2-year-old bucks. In 1959, Klein listed the parasites known to occur in Sitka black-tailed deer as well as reporting his then-routine population studies.

Range studies--The earliest documented surveys designed to assess range conditions for Sitka black-tailed deer were those by Olson in 1953 [Nelson, 1953]. He (and Klein beginning in 1955) apparently established and read transects designed to assess the degree of use of key browse species following winter use. In 1956, Klein expanded these efforts by initiating a study of the nutritive quality of various deer browse species [Nelson, 1956]. As part of his efforts in 1957 to standardize

procedures for assessing population trends and range conditions, Klein established permanent range plots and exclosures in 17 different sites [Klein, 1957]. He also established permanent browse inventory transects in each Deer Management Index Area. Using the line-intercept technique, Klein recorded the percentage of use and the vigor of browse plants along these transects. The transects were read annually through at least 1966.

Research Conducted from 1959 through 1970

Population studies--Following transfer of wildlife management authority to the State of Alaska in 1959, deer investigations initially remained essentially unchanged [ADF&G, 1960]. Winter beach counts from airplanes and boats continued as did the winter mortality surveys initiated by Olson in 1952. Harry Merriam, the State's new deer biologist in Petersburg, initiated fall, aerial, alpine composition counts and forest counts to augment numerical data from winter beach counts, although the forest counts were discontinued after 1 year. In 1959, Merriam also expanded data collections on deer harvests by conducting personal interviews with hunters and by collecting jaws from successful hunters for use in determining age composition of harvested animals [ADF&G, 1960].

These studies continued through 1960, but they were expanded to include Prince William Sound's transplanted deer population [ADF&G, 1961]. There, meat processors were contacted, and a temporary employee was hired to check hunters in the field in an effort to augment harvest information gathered through questionnaires. In southeastern Alaska, the State's parasitologist, Ken Neiland, reviewed parasitism in deer and proclaimed it to be "light." Paul G. Garceau, another State biologist in southeastern Alaska, analyzed wolf scats collected in 1958 and found that 95.5 percent contained deer remains [ADF&G, 1961]. Merriam measured metacarpal bones of harvested deer and found that their length was related to the sex and age of the animal. Early in 1960, results of the studies on deer mortality patterns conducted by Olson and Klein from 1952 until 1958 were published [Klein and Olson, 1960]. With the goal of assessing the effect of wolf predation on a deer population which had not previously been subjected to predation, 4 wolves approximately 19 months old (2 males and 2 females) were released in October, 1960 on Coronation Island in southeastern Alaska [Merriam, 1965a]. An estimate was made of the deer population on this Island, and vegetation transects were established and read to provide an opportunity to measure future vegetational changes resulting from lowered deer numbers [Merriam, 1965b].

Deer investigations in 1962 and 1963, in addition to the standard procedures developed earlier, were expanded to include population data from counts conducted along the Mitkof Highway [Merriam, 1963]. Merriam [1962] evaluated succinylcholine chloride administered with a crossbow as an immobilization technique and individually ear-tagged 28 deer during winter 1962. Some reproductive tracts were collected in 1962 for future analysis [Merriam, 1963]. Also in 1962, interviews were used in southeastern Alaska and on Kodiak Island to assess harvest [Merriam, 1963], but in 1963 the Kodiak biologist began to use a postal survey for harvest assessments [Merriam and Batchler, 1963].

As part of their continuing effort to develop techniques for assessing deer numbers, biologists on Kodiak Island conducted experimental aerial surveys of randomly selected plots in deer wintering areas and attempted track counts on other parts of the Island in 1963 [Merriam, 1965b]. Use of these techniques was discontinued after several years. In 1964, initial attempts were made to assess deer numbers using pellet group counts in Prince William Sound and southeastern Alaska [Merriam, 1965]. Transects were established in 1964 and read that year, in 1965, and again in 1966, at

which time the value of this technique was determined to be questionable because of the slow and variable rate of pellet decomposition [Merriam, 1966].

By 1964, the wolves on Coronation Island had increased to about 12 animals (an additional adult female had been released in 1963). Their influence on the island's deer population was obvious by this time, and the vegetation on Coronation Island was already reflecting improvement as a result of decreased browsing pressure [Merriam, 1965a].

Noteworthy new activities conducted or initiated in 1965 were the collection of stomach samples for food habits analysis, collection of reproductive tracts, and observation of deer feeding on Kodiak Island [Merriam, 1966]. Based on the latter observations, it was determined that fireweed (*Epilobium angustifolium*) was an important deer food during the summer months on Kodiak. Also during 1965, aerial alpine surveys were continued on Kodiak Island and in Prince William Sound; hunter interviews were conducted statewide to assess deer harvests. In 1966, these studies were continued with the exception that aerial surveys at Kodiak were conducted in winter rather than in the alpine during summer [Merriam, 1967]. Merriam, reporting in 1967, analyzed 14 recoveries from deer tagged from 1952 through 1965. All of these deer were recovered within a few miles of the tagging site.

Population studies from 1967 through 1969 continued with little deviation from techniques used in prior years. In 1967, however, a sample of deer jaws was collected from hunter kills in an attempt to determine the utility of sectioning incisors for age determination [Merriam, 1968]. Although no report of findings could be found, I understand [Merriam, personal communication] that cementum layers were correlated to the age of deer on Kodiak Island and tooth sectioning appeared at first to be a useful technique for age determination. However, it was later determined that application of this technique to southeastern provided unreliable results.

On the basis of his personal experience and the accumulated knowledge of that time, Merriam [1968] concluded that the best index of deer population levels was a combination of data showing hunter success/unit effort, winter mortality, range use, and age composition of harvested deer. He also concluded that winter severity is the major limiting factor to deer populations in Alaska. This interpretation had been alluded to in the reports of several of his predecessors and by Merriam in earlier reports, but this seems to be the first time that these concepts were clearly presented. Merriam reiterated these concepts in his report on 1969 studies and in a paper presented at the northwest section of the Wildlife Society in 1970. Perhaps they were most clearly expressed in the following excerpts from Merriam [1971b].

> "Since 1964 average winter temperature was lower than for many preceding years, deer losses were higher and hunter success poorer. Hunting is not considered sufficiently intensive to control deer populations in Alaska. Many areas receive little or no hunting, yet populations fluctuate in these areas similar to those which receive higher hunting pressure. The major contributing factor to these fluctuations is probably food availability as controlled by winter snow depths. Availability of the higher quality food species on the range is limiting."

Range studies--Like population studies, research on deer ranges followed previously developed patterns with the onset of statehood. Browse utilization plots and browse inventory transects established by Klein in 1957 were routinely analyzed from 1959 through 1966. Early in 1963, Klein completed his Ph.D. dissertation entitled "Interrelationships of Deer and Their Range in Alaska" [Klein, 1963]. This work, based on intensive field studies during 1959, 1960, and 1961, did much to elucidate

the ecology of the Sitka black-tailed deer in southeastern Alaska, particularly the relationships of the animal and its range.

Likely as a result of Klein's earlier studies, browse samples were collected in 1963 and 1964 and again in 1966 for protein content analyses [Merriam, 1965, 1967]. By this time, biologists were aware of the complex interactions of browse quality and quantity on herd welfare and were making major efforts to enhance their understanding of this relationship.

With an improved general understanding of deer ecology in the midsixties, State biologists' investigative efforts began to show redirection and improved coordination. It was apparent to Merriam that clearcut logging posed immediate- and long-term threats to the continued welfare of southeastern deer populations. As early as 1964 [Merriam, 1965b], he began to review existing records of logged areas as a preliminary step in establishing a research project to quantify the effects of logging on deer habitat. These efforts continued intermittently through 1968; sites for study were selected and their cutting dates established through review of existing records and core sampling [Merriam, 1968], but for various reasons the study never materialized.

Beginning about 1963, there was a tendency in the Alaska Department of Fish and Game (ADF&G) to selectively isolate specific questions to be resolved with intensive research efforts. The first such research study was initiated in June 1963 when the Forest Service experimentally sprayed a portion of Skowl Arm on Prince of Wales Island with a quarter-pound per acre of *d*ichloro-*d*iphenyl-*t*richloro-ethane (DDT) for controlling black-headed budworms. In cooperation with the Forest Service, Merriam [1965b] collected samples of *Vaccinium ovalifolium* and *Cornus canadensis*, important deer foods, before spraying and twice following spraying. He also collected deer before and after spraying to measure accumulations of DDT in tissues.

Analyses of plants and samples of skeletal muscle and adipose tissue reflected the following: First, immediately after spraying (July), plants showed high concentrations of DDT; by December of that year, concentrations had declined considerably. Second, following spraying, DDT was absent in muscle tissue as it had been prior to spraying, but it was present in adipose tissue. In March 1965, additional deer were collected in Skowl Arm, and DDT was still present in adipose tissue [Merriam, 1966].

Another study established in 1963 was designed to experimentally measure the effect of deer utilization on *Vaccinium*. By annually clipping selected plants [Merriam, 1965b], 20, 40, 60, 80 and 100 percent of utilization was simulated. By 1965, plants subject to 80 and 100 percent of simulated utilization annually evidenced some decrease in vigor. This study was continued through 1968 when Merriam drew these conclusions: First, there was no loss of vigor below 40 percent of utilization. Second, 60 percent of utilization resulted in 10 percent dead twigs. Third, 80 percent of utilization resulted in 50 percent dead twigs. And, fourth, 100 percent of utilization resulted in 80 percent dead twigs.

Merriam [1968] also initiated a study designed to compare snow accumulations under the forest canopy with accumulations in the open. He established a transect on Mitkof Island from sealevel to an elevation of 1,500 feet, periodically measured snow depths at elevation intervals of 100 feet in the open and under the timber canopy, and counted deer tracks between each elevation interval. After the first year, Merriam concluded that snow accumulation under a timber canopy was about half that in the open. He also concluded that, generally speaking, deer did not use areas where snow depths exceeded 12-15 inches. Later, Merriam [1971c] modified the first conclusion by stating that snow depths beneath the forest canopy are about a third to half of those found in open areas. He also stated, after further studies, that 18 inches of accumulated snow appeared to be the limit of deer use for an area [Merriam, 1977b].

In two other studies accomplished in cooperation with the USDA Forest Service, Merriam evaluated the effects of the herbicide 2-4-D on deer food species and tested the response of *Vaccinium ovalifolium* to fertilization with granular urea (46 percent nitrogen). Merriam concluded that application of 2 pounds per acre of 2-4-D to control red alder (*Alnus rubra*) resulted in a total kill of *Vaccinium ovalifolium* where it was not protected by a forest canopy. This herbicide also killed devilsclub (*Oplopanax horridus*) and rusty menziesia (*Menziesia ferruginea*), but none of the forbs were permanently affected. One fertilization study, which was initiated in May 1969 and involved treating 1,500 acres with 400 pounds per acre of urea, resulted in the conclusions that annual growth was 6.1-percent greater in fertilized areas and that protein content averaged 7.04 percent in control areas and 8.56 percent on fertilized areas [Merriam, 1971a]. Another fertilization experiment involved treatment in June 1970 of three 0.01-acre plots with 200 pounds, 400 pounds, and 800 pounds per acre of urea (46 percent nitrogen). Based on this experiment, Merriam [1973] concluded that addition of nitrogen to the soil had no influence on annual growth of *Vaccinium ovalifolium*. In still another study, rather poorly documented, Merriam [1971c] compared production of *Vaccinium ovalifolium* on good and poor deer winter ranges. On "good" ranges, production averaged 317 pounds per acre, dry weight, and on "poor" ranges it averaged 44 pounds per acre, dry weight.

Investigational Activities Conducted Since 1970

Although surveys and inventories designed to provide annual assessments of hunter harvest, hunting pressure, deer population trends, and habitat conditions have been continued to the present, the Alaska Department of Fish and Game essentially did no deer research from 1970 until July 1977. The single exception was an analysis of the two methods for calculating deer harvest data presented in use (hunter interviews and mandatory hunter report cards). This study [see Ballard and others in these proceedings] resulted in the conclusion that hunter interviews are the most efficient method of the two for gathering harvest data. Although harvest reports are superior to interviews as a means of gathering information on hunting effort and success at specific locations, these investigators suggested that the two systems be continued concurrently until sufficient data are acquired from the harvest reports to answer needs for information on hunting effort and success at specific locations.

Although the studies conducted by Dr. Barrett for U.S. Plywood Champion Papers, Inc. [Leopold and Barrett, 1972], were considered "reconnaissance surveys," I feel they should be mentioned here for several reasons. First and foremost, these studies represented an objective and independent review of existing information on deer ecology in southeastern Alaska. Second, Barrett conducted several field studies which contributed to our knowledge of deer ecology, particularly during the stressful winter months. In terms of deer mortalities since 1900, the winters of 1968-69 and 1970-71 were possibly two of the most severe, and many of the problems postulated by previous investigators actually came to pass. One of Barrett's conclusions was that:

> "On Admiralty Island, the key winter ranges are generally situated in mature conifer stands that have opened up enough to allow the growth of *Vaccinium* and other browse plants. To this extent, Alaska deer may be considered affiliates of climax forest vegetation rather than subclimax as is their normal relationship in more southerly ranges."

Arthur Bloom, a Forest Service fisheries scientist working in the Kadashan Bay area of Chichagof Island, independently conducted a study during the 1975-76 winter relating winter deer use to soil and forest community types [Bloom, 1978]. In

addition, he quantified and compared snow depths under various canopy types. Bloom concluded that, if large blocks of low-elevation timber in his study area were clearcut, the carrying capacity of its winter range for deer would decline.

Another study, by Billings and Wheeler of the Forest Service, is, I understand, still in progress. These investigators [see Billings and Wheeler in these proceedings] found that crude protein content of winter-collected samples of *Vaccinium ovalifolium* growing on different ecosystems varied considerably between ecosystems. Perhaps even more interesting were data indicating that the crude protein content of this forage plant was greater 200 feet into a stand than it was at the edge or in the open.

Conclusions or "State of the Art"

Because I feel strongly that this paper should serve as more than an annotated bibliography of documented Alaska deer studies, I would like to conclude with some personal beliefs regarding the "state of the art" and future research needs. The rather crude information upon which we base present deer management is barely adequate to fill current needs. The one obvious exception, of course, is our lack of understanding of the relationship between wolf populations and deer. Nevertheless, given current deer numbers, no further reductions in deer habitat, and no increased human demands upon this resource, we could continue to adequately "manage" deer forever.

I cannot state too strongly, however, that our present rather superficial understanding of deer ecology is altogether inadequate for meeting future needs. We are fortunate in Alaska in that the habitat base for our deer resource is still largely intact. It is apparent, though, that over much of this deer range unregulated timber harvesting could perhaps largely eliminate the species in harvestable or even observable numbers. It behooves all of us in the Department of Fish and Game and in the Forest Service to learn much more about this deer and its habitat requirements, particularly as they are affected by timber harvesting, so we can insist on long-term management of deer and timber consistent with the needs of future generations of Alaskans and other Americans. I sincerely hope that recently initiated cooperative studies by our agencies will ultimately provide the knowledge required for us to fulfill this public trust.

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The Forest Service Wildlife Program in the Alaska Region

by

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The fishery and wildlife program in the Alaska Region of the Forest Service has been marked by change and growth. One of the distinguishing characteristics of an agency is its ability to respond to the changing world around us, to new ideas generated by many disciplines. The change in and growth of the Alaska Region's wildlife program is what I want to talk about today.

But first, What are the authorities of the Forest Service to manage fish and wildlife habitat on National Forest System lands?

Authority for wildlife management of the national forests stems from the broad powers granted to the Secretary of Agriculture under the Organic Act of 1897 and Transfer Act of 1905, which authorize the Secretary to regulate the occupancy and use of the national forests. The Multiple Use-Sustained Yield Act of 1960, the Endangered Species Act of 1973, the Sikes Act of 1974, the Forest Rangelands and Renewable Resources Planning Act of 1974, and the National Forest Management Act of 1976, broaden and strengthen these powers.

Forest Service responsibility for wildlife emphasizes protection and enhancement of habitat. Fish and wildlife, as such, are managed by State fish and game agencies. The respective responsibilities of the States and Forest Service toward wildlife are well defined in a master Memorandum of Understanding between the Forest Service and the State which provides a continuing cooperative approach to wildlife management on national forests. This memorandum is supplemented by many cooperative agreements between the two agencies. The Alaska Department of Fish and Game, as well as other State and Federal agencies, are included at all levels of the Alaska Region's wildlife planning and management activities. Close cooperation with private landowners will also become increasingly important as lands are conveyed to citizens and to Native villages and corporations.

Our objective is to provide quality hunting, fishing, and recreational opportunities and subsistence use where necessary, as well as opportunities to observe and photograph wildlife. The Forest Service wildlife program is one of long standing.

But, until recently, it has not enjoyed the prominence it merits. The custodial nature of forest management, which existed before 1950, required relatively little in the way of fish and wildlife management, and the technology in those days was far from what it is today. Large-scale timber harvesting, beginning early in the fifties, triggered concern about the impacts on wildlife and fisheries resources. These concerns led to studies, programs, and ever-changing policies for protecting those resources.

In 1949, the Alaska Forest Research Center (AFRC) began their studies of the effects of logging on salmon streams at Hollis near Ketchikan. In 1956, the AFRC was joined by the Fisheries Research Institute (FRI) of the University of Washington. FRI researched the effects of logging on salmon until 1962. Several publications and theses resulted from their work.

Research at the Little Port Walter research station of the National Marine Fisheries Service, although not geared to effects of logging, resulted in major contributions to the habitat requirements of salmonids. These results were a significant aid to forest management of the salmon habitat.

The realization of the importance of small tributaries to rearing species--coho, Dolly Varden, cutthroat, and Steelhead trout--changed forest practices so these streams received greater protection. When it was demonstrated in Oregon that removal of the forest canopy along small streams susceptible to warming by the sun could have adverse effects on the production of rearing species, a study was conducted by the Forest Service in Alaska. From that study, guidelines for protection were formulated.

In 1962 when funding became available for fisheries enhancement projects, an enhancement program was started. Since then, more than 200 habitat improvement projects costing more than $2 million have been completed on Alaska's National Forests. The Sikes Act (P.L. 93-452) called for a comprehensive fishery and wildlife plan in cooperation with the States and has given fishery and wildlife enhancement programs added clout. Today, many of the projects developed with the State of Alaska have been completed or are underway.

The Forest and Rangeland Renewable Resources Planning Act (RPA) called for a complete wildlife assessment. This includes numbers of species, association of species with habitat, supply and demand, and definition of opportunities for increased production. This Act caused changes in program planning.

Increasing emphasis on nonconsumptive use of wildlife and interest in nongame species caused an addition of these programs to those already in effect. We have conducted surveys and studies to determine the species of birds on national forest lands and adjacent coastal waters and the effects of clearcut logging on changes in species composition and numbers of birds and small mammals. Offshoots of the Threatened and Endangered Species Act are the Memorandum of Understanding with the U.S. Fish and Wildlife Service for the protection of bald eagle habitat, the establishment of a bald eagle management area in the Seymour Canal area off of Admiralty Island, and active information and education programs on the two forests of the region. These include programs on plants, animals, fish, and amphibians.

Surveys and studies have been initiated on the waterfowl of the Copper River and Stikine River deltas, the life history and habitat requirements of the Vancouver Canada goose (unique to the Tongass National Forest), and the effects of clearcut timber harvests on Sitka black-tailed deer. Studies are now proposed for some of the furbearers, such as land otter and marten. Prescribed burning for enhancement of moose habitat has been done on the Kenai Peninsula, and burning is planned on a pilot-study basis for the Stikine River delta waterfowl area.

An intensive land management planning effort has been underway for about three years. Baseline data needed for planning has contributed to the fishery and wildlife programs. The interdisciplinary team (IDT) approach was started as part of the overall land management planning process several years ago. The IDT is the most powerful tool yet to appear to ensure the quality of prescriptive and project planning.

Methods used to protect the habitat against overuse include improving access to remote spots and construction of camping areas and cabins. Forest Service cabins on trail systems, lakes, bays, and estuaries in southeast and south-central Alaska allow many added thousands of hours of hunting, fishing, and opportunity for observation and photography each year on the national forests.

In recent years, aquaculture has assumed an ever increasing role in Alaska as a means of supplementing the production of natural salmon runs. Through the use of environmental statements and assessment reports, we have participated in planning with the State and the private sectors for several active aquaculture projects in the Tongass and Chugach National Forests. Increased activity and participation is anticipated for the future.

Recently, funding has dramatically increased for fish and wildlife programs. This allows a level of staffing far more commensurate with the importance and needs of the fish and wildlife resource on national forest lands. The number of fish and wildlife staff members has increased from 4 biologists in 1972 to more than 30 in fiscal year 1978. This funding also provides for an accelerated habitat program designed to correct many of the shortcomings of past management. This includes habitat improvement projects, surveys, and studies to provide managers with an improved information base. In 1977, the total wildlife budget was less than $1 million. In fiscal year 1978, it was $3.2 million. This level of funding is expected to be maintained or increased. The 1978 budget included a special appropriation of $600,000 for habitat improvement. This amount is expected to be available for at least 3 more years.

The Fish and Wildlife Program Manager concept is now in effect on all forests and areas in the region. The program manager is a staff assistant to the forest supervisor and directs the activities of the staff of biologists. This puts wildlife on an equal baiss with all other resource programs.

The highlights of the fish and wildlife program in the Alaksa Region have been presented in the light of growth and change. Each year more studies and surveys are being initiated by the Forestry Sciences Laboratory, Region 10, Alaska Department of Fish and Game, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and other agencies. Each year we increase our knowledge of forest management as the data base broadens and becomes more usable. Thus, we are better capable of responding to the changing world around us.

Ecology and Habitat Management

A major part of the conference was devoted to deer-habitat interactions, beginning with a discussion by A.S. Harris and W.L. Farr of forest ecology and silvicultural principles governing timber management in southeast Alaska. The paper authored by R.F. Billings and N.C. Wheeler in this section was presented in summary at the conference by W.L. Sheridan. F.L. Bunnell departed completely from the text of his prepared paper (which is printed here) and delivered a perspicacious lecture on the acquisition and handling of relevant data. For those ideas, readers may contact Dr. Bunnell.

Timber Management and Deer Forage in Southeast Alaska

by

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and

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Southeast Alaska is that portion of the State extending from Dixon Entrance to Yakutat, a distance of 540 miles (870 kilometers) including 24 million acres (9.7 million hectares) of land area. Although this is just over 5 percent of the entire State, southeast Alaska contains the major part of Alaska's timber resources.

The landscape is dominated by rugged mountains and conifer forests. A trip by ferry can give the traveler the feeling that the vegetation is everywhere the same. Mountains rise more or less steeply from the water's edge and appear to be covered with unbroken forests to the timberline. On closer inspection, however, we find a variety of ground cover including tideland meadows, muskegs or bogs with or without scattered tree cover, and alpine forests and meadows. The conifer forest, which covers 46 percent of the land area, consists of a mosaic of stands of varying textures, densities, crown sizes, and subtle colors.

The Western Hemlock-Sitka Spruce Forest Type

The forest of southeast Alaska is a segment of the temperate rain forest that extends along the Pacific coast from northern California to Cook Inlet, Alaska. This is the western hemlock-Sitka spruce [*Tsuga heterophylla* (Raf.) Sarg.-*Picea sitchensis* (Bong.) Carr.] forest type, so named for its two most common and commercially important tree species.

The hemlock-spruce type spans some 19 degrees of latitude along the coast. In contrast to areas further inland, the climate is characterized by cool summers and relatively warm winters. Precipitation is high. Toward the north, summer rains are frequent, and there is little summer drought [Patric and Black, 1968]. Summer drought is more promounced toward the south, but it is greatly offset by summer fog [Isaac, 1946].

The amount of solar energy reaching the earth decreases with increases in latitude. A convenient measure of this heat energy is the number of growing-degree days. A growing-degree day is defined as the mean daily temperature above a specified threshold. We use 5° C as a threshold, because this is about the temperature at which plant growth begins. Within the hemlock-spruce type, the mean annual sum of growing-degree days is about 2,511 days at Brookings Oregon; 1,942 days at Forks, Washington; 1,408 days at Annette; 1,014 days at Juneau; and 819 days at Yakutat (table 1). It is important to keep this trend in mind when interpreting studies made at different locations within the hemlock-spruce type.

As one moves northward, this decrease in heat energy results in a shorter growing season, a reduced rate of biological acitivity, and a decrease in forest site productivity. It also results in a higher percentage of precipitation in the form of snow and a greater depth and persistence of snow on the ground. Snow is especially important in southeast Alaska where winter weather along with predation by wolves have historically determined the status of deer populations [Alaska Department of Fish and Game, 1977].

We measure forest site productivity in terms of total height that the average dominant and condominant hemlock and spruce will attain at 100 years of age. We have found that the site index decreases at the rate of about 3.4 units per degree of latitude. The average site index of hemlock and spruce in Washington State is about 145, and in southeast Alaska, about 113.

Southeast Alaska's forests contain fewer tree species than do the coastal forests of British Columbia and the Pacific Northwest, and species diversity decreases with increasing latitude. Nine conifer and 22 broadleaf species attain tree size. Of these, four species are sought for commercial harvest--western hemlock, Sitka spruce, western redcedar (*Thuja plicata* Donn) and Alaska-cedar [*Chamaecyparis nootkatensis* (D. Don) Spach]. Mountain hemlock [*Tsuga mertensiana* (Bong.) Carr.] is logged along with western hemlock when encountered in mixed stands, and it is sometimes difficult to tell the two species apart. Pacific silver fir [*Abies amabilis* (Dougl.) Forbes] and subalpine fir [*Abies lasiocarpa* (Hook.) Nutt.] occur in limited areas and may be cut, although neither species is sought for harvest. Shore pine (*Pinus contorta* Dougl. var *contorta*) is used locally for firewood and for Christmas trees, but it is seldom found in dense commercial stands. Black cottonwood (*Populus trichocarpa* Torr. & Gray) has been harvested occasionally and tested for use as dissolving pulp, but it is not being harvested today. Red alder (*Alnus rubra* Bong.) is used locally for firewood, carving, and smoking fish.

The forests contain many shrub species; Viereck and Little [1972] recognized 72 important species. Many of these shrubs are characteristic of the dry interior and appear in southeast Alaska in only the drier transition zones.

Composition of tree species varies by location, topography, drainage, soil type, and stand history. Based on the number of trees that are 1 inch (2.4 cm) or more in diameter on commercial forest land, average species composition of a stand is western hemlock, 73 percent; Sitka spruce, 12 percent; western redcedar, 5 percent; Alaska-cedar, 5 percent; mountain hemlock and other softwoods, 4 percent; black cottonwood, red alder, and other hardwoods, 1 percent [Harris and Farr, 1974].

TABLE 1--Mean annual climatic data for representative stations within the natural range of Sitka spruce, 1950-74

Station	Latitude, North	Longitude, West	Degree days[1]	Precipitation	Snowfall	Frost-free days
			No.	*Cm*	*Cm*	*No.*
Brookings, Oregon	42°03'	124°17'	2,511	204.9	1	294
Otis, Oregon	45°02'	123°56'	2,131	250.2	13	192
Forks, Washington	47°57'	124°22'	1,942	297.8	43	190
Quantsino, B.C.	50°32'	127°37'	1,697	235.2	58	200
Langara, B.C.	54°15'	133°03'	1,204	165.5	71	241
Annette, Alaska	55°02'	131°34'	1,408	298.0	142	210
Sitka, Alaska	57°04'	135°21'	1,221	214.4	114	196
Juneau, Alaska	58°22'	134°35'	1,014	134.5	279	129
Yakutat, Alaska	59°31'	139°40'	819	329.2	574	112
Cordova, Alaska	60°30'	145°30'	851	226.6	340	111
Seward, Alaska	60°07'	149°27'	989	151.4	221	153

[1]Base 5° C

Species composition of trees on land classified as noncommercial forest land consists largely of hemlocks, cedars, and shore pine [Harris and Farr, 1974].

Timber Management in Southeast Alaska

About 11 million acres (4.4 million hectares), or 46 percent of the land area of southeast Alaska, is forested [Hutchison and LaBau, 1975]. Of this, 6 million acres (2.4 million hectares) is classified as productive forest land capable of producing 20 cubic feet per acre (1.4 cubic meters per hectare) per year and having a standing timber volume of at least 8,000 board feet per acre.[1] Preliminary data show that about 14 percent of the productive forest land is within one-half mile (0.8 kilometers) of tidewater and below 500 feet (150 meters) in elevation. Much of this productive forest land is valued as winter habitat for deer, as well as for its valuable and accessible timber.

[1]Based on Scribner log rule; data is available at the Forestry Sciences Laboratory in Juneau, Alaska.

Under current planning, much of the total productive forest land is or will be reserved from timber cutting. Because of pending changes in landownership and classification, we won't attempt to speculate on future management of this land. Instead, let's look at some of the characteristics of the forest--first at the age structure. This will lead us to consider such things as forest succession and the reasons for some of our current management practices and some future possibilities.

It has been convenient for timber managers to classify productive forest land on the basis of stand age. Stands less than 150 years of age are arbitrarily classified as young growth, and stands over 150 years of age are classified as old growth. Young-growth stands are essentially even-aged, low in defects, and still capable of adding growth. Old-growth stands are more variable in age and defects and are beyond the age of optimum growth.

Structure and Management of Old-Growth Stands

Old-growth stands cover about 87 percent of the productive forest land area of southeast Alaska [Hutchison and LaBau, 1975]. Most of these stands are in natural condition, although some of the more accessible stands have been high graded in the past for high-quality logs. We often speak of old-growth stands, mature stands, overmature stands, and climax stands, as if there were no difference between these terms. This has blurred the fact that old-growth stands tend to be highly variable.

We recently began a study of the structure of old-growth stands. Our objective is to gain a better insight into the possibilities and problems of applying uneven-aged silviculture in southeast Alaska. We have learned so far that the age and decay structure of old-growth stands is indeed highly variable. Some stands are truly all aged, and others consist of a single-age class. Still others have two or three well-defined age classes separated by 100 to 150 years between classes.

Old-growth stands in the 150-to-200-year age class are generally sound and even-aged in structure. Most are typically dense and have a fairly limited range in diameters. At about this age, overstory trees begin to fall victim to insects, disease, or wind. As the stands begin to open, more light reaches the forest floor, and tree regeneration becomes established along with other plants. Hemlock is more tolerant of shade than is spruce or cedar, so stands gradually convert to hemlock. Depending on the way in which stands are opened, old-growth stands tend to have predominantly two, three, or more age classes.

Site productivity of old-growth stands is gradually reduced as raw, undecomposed humus builds in the forest floor [Taylor, 1933]. Trees that develop in the shaded understory tend to grow very slowly because of insufficient light. Understory trees are more defective, because they are easily damaged by falling limbs or trees, or they may be infected by dwarf mistletoe. Total stand volume diminishes over time because of decay in standing trees, inefficient use of growing space, and reduced soil productivity. Loss from decay eventually offsets growth, and in advanced successional stages net stand growth may be negative. The pattern of late succession is extremely variable because of species composition, soil, drainage, and the effect of chance damage from wind, insects, or other factors.

Most trees in a typical old-growth stand are western hemlock. There are relatively few spruce, especially in the smaller diameter classes. Cedars are rare on most better sites and more common on the less productive timber sites. For trees of equal diameter, hemlock are generally older than spruce. Advanced regeneration also tends to be quite old. Five- to 6-inch (13- to 15-centimeter) hemlock average about

120 years old; spruce are somewhat younger, about 70 years old. Small sawtimber hemlock, 11 inches (28 centimeters) in diameter, average 180 years old, and similar sized spruce are about 110 years old. On the average, most spruce over 11 inches (28 centimeters) in diameter and hemlock over 5 inches (13 centimeters) are at least 100 years old (fig. 1).

Hemlock is generally more defective than spruce. About 35 percent of the sawtimber-sized hemlock and 20 percent of the spruce have some external indicator of decay, such as basal scars, trunk scars, frost cracks, broken tops, or conks [Farr and others, 1976]. On the average, total defect accounts for about 31 percent of the gross board foot volume of old-growth stands. For hemlock especially, there is considerable volume loss in the older age classes (fig. 2).

From the standpoint of timber production alone, it is not desirable to manage uneven-aged, defective, near-climax stands. Rather than attempt to manage old-growth stands, it is preferable to clearcut and begin over with young, rapidly growing stands. From the standpoint of deer habitat, however, it might be preferable to maintain a forest cover.

Theoretically, it should be possible to manage some old-growth stands under a form of selection cutting in which a few trees or groups of trees are periodically removed. A nearly continuous, all-aged overstory would be maintained to provide shelter and forage. Such stands, however, would produce far less timber than stands managed under an even-aged silvicultural system. It would also be costly to remove trees without damaging the residual stand, because spruce and hemlock have shallow roots and thin bark and much of the topography of southeast Alaska is steep. In other situations where maintaining existing deer habitat is of highest value, it might be preferable to restrict management to salvaging trees damaged by wind, insects, or other natural causes.

Young-Growth Stands

Young-growth stands are essentially even-aged. They became established following blowdown, fire, insect epidemic, or logging. In the case of primary succession, stands become established following a glacial retreat, land uplift, or landslide. Young-growth stands are often classified by stand size, such as seedlings, saplings, poles, and sawtimber.

About 13 percent of the productive forest land area of southeast Alaska is now covered by young-growth stands. About 290,000 acres (117,000 hectares) of old-growth forests have been harvested in this century [Sandor, 1978]. About 14,000 (5,700 hectares) are now being harvested annually by clearcutting.

Succession Following Clearcutting

After clearcutting, varying amounts of logging residues are left on the ground. The amount and distribution depends on the age and defectiveness of the stand that was logged, utilization standards, type of logging, and other factors [Ruth and Harris, 1975]. Large residues slowly decompose. They can interfere with forest regeneration, future stand management, and access by deer for many years.

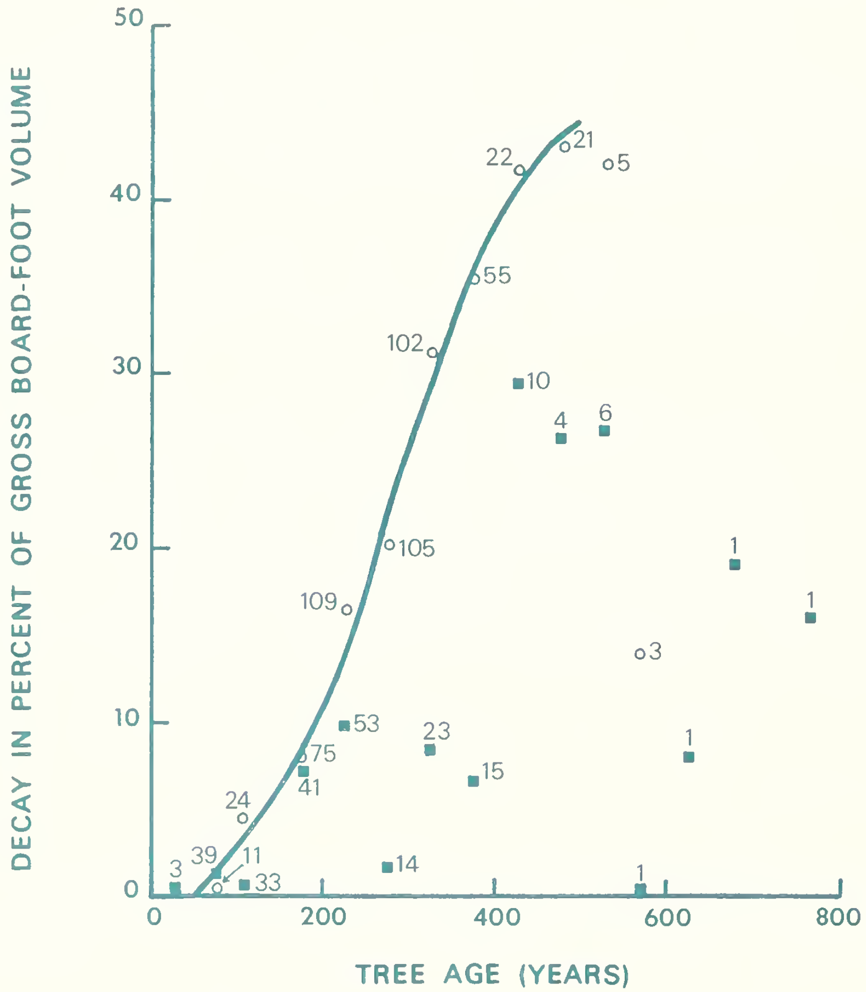

Figure 2--Sitka spruce and western hemlock: Decay and age relationships in 50-year-old stands
[*Data are averages for sample trees in southeast Alaska. Numbers show size. Circles and curve are for western hemlock; squares are for Sitka spruce. Source: Farr and others, 1976.*]

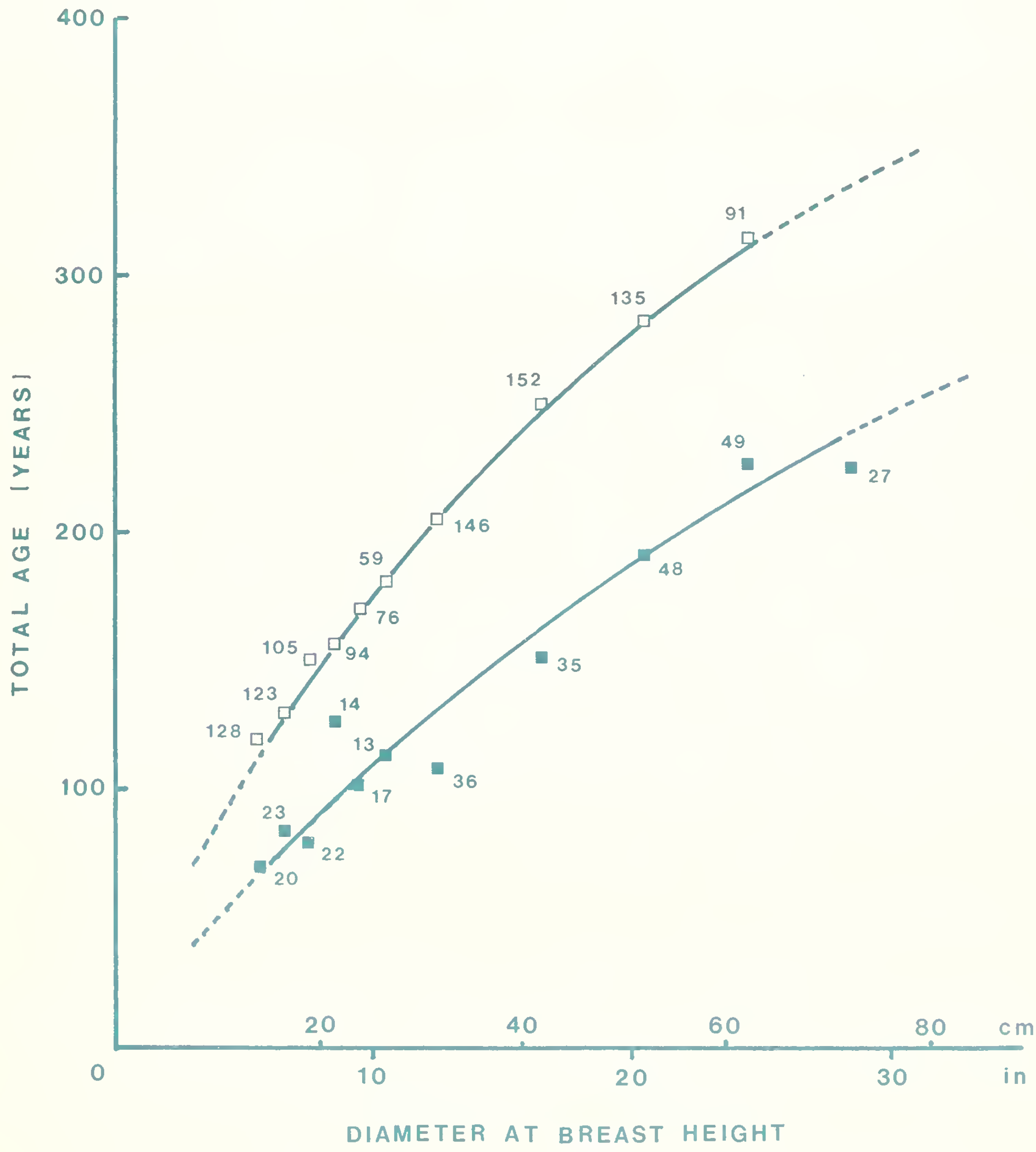

Figure 1--Sitka spruce and western hemlock. Age and diameter relationships in old-growth stands

[Data are averages of 2- and 4-inch-diameter classes of sample trees in southeast Alaska. Numbers show diameter classes. Open squares are for western hemlock; closed squares are for Sitka spruce.]

Following clearcutting, the soil is warmed, and biological decomposition of the forest floor is accelerated. This results in an increase in available nutrients and faster plant growth for several years. There is an immediate reinvasion of vegetation. Species diversity can be great, and growth rates high. The number and density of plant species depends on characteristics of the understory of the logged stand, soil, drainage, time of logging, degree of soil disturbance, availability and abundance of seed, weather, and other factors. Summer forage is increased, but the increase may be of little value to deer if there is abundant summer forage already available in surrounding areas. In winter, clearcut areas have a deep snow cover that prevents access or use by deer.

Hemlock and spruce seedlings are usually present beneath old-growth stands, and many survive logging. Additional seedlings become established soon after clearcutting, along with shrubs, herbs, and forbs. Eight years after logging on the Maybeso Experimental Forest near Hollis, the new stand contained about 4,300 conifer seedlings per acre (10,600 per hectare); 53 percent of the stand was hemlock, 41 percent spruce, and 6 percent cedar [Harris, 1967].

Conifer development occurs rapidly. On good sites, most forbs, grasses, and shrubs are shaded out within 15 to 20 years. For example, 19 years after logging of a good site on the Maybeso Experimental Forest, dominant hemlock and spruce ranged from 19 to 22 feet (5.8 to 6.7 meters) in heights with stocking ranging from 3,000 to 6,000 stems per acre (7,400 to 14,800 per hectare).

From this point on for many decades, conifer stands remain dense and will offer cover for deer but little or no forage. A study is now underway to quantify species and amount of vegetation in the understory of naturally developing stands.[2/]

Yield tables are available which describe the first 150 years of natural stand development of hemlock-spruce stands in southeast Alaska [Taylor, 1934]. These tables show that rapid growth takes place in young stands for the first few decades. Culmination of mean annual increment of wood fiber takes place at about age 70 in unmanaged stands. The growth rate slows slightly after 70 years. Present management plans call for a rotation age of about 100 years. With wood fiber production the goal, rotation length might logically be reduced for natural stands and reduced even further in stands which are periodically thinned.

Intensive Management

With increased demand for timber in the future, we expect that timber management will become more intensive. Under intensive timber production goals, many stands will be first thinned at age 10-20 years. Spacing will range from about 10 by 10 feet (3 by 3 meters), or 436 stems per acre (1080 per hectare), to 16 by 16 feet (5 by 5 meters), or 170 stems per acre (420 per hectare), depending on location of the stand and objectives of management. Thinning will, in effect, prolong the interval of time between clearcutting and crown closure. The purpose of thinning early in the life of a stand is to reduce tree stocking and hasten individual tree development. The first thinning might be followed by one to several additional thinnings to

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[3/] Robuck, Wayne. Understory vegetation in thinned and unthinned hemlock-spruce stands in Alaska. (This study plan is available at the Forestry Sciences Laboratory in Juneau, Alaska.)

maintain rapid development of selected crop trees and to salvage anticipated mortality. Sufficient stocking will be maintained to fully utilize the site for timber production.

It might be possible, however, to maintain thinned stands at less than full stocking levels to encourage greater development of understory vegetation for deer. Less than full stocking, however, might result in additional conifer regeneration and the subsequent development of a two-storied conifer stand. For example, in a study of partial cutting in a 90-year-old even-aged stand, we found that removal of about a third of the stand resulted in dense but slow-growing western hemlock becoming established in the understory [Farr and Harris, 1971].

We are optimistic that thinning will have the effect of producing second-growth stands in some parts of southeast Alaska that offer cover for deer and are open enough to produce accessible forage during parts of some winters. We have a study underway to determine changes in understory vegetation in response to thinning.[2/]

Summary and Conclusions

In southeast Alaska, about 87 percent of the productive forest land is still occupied by old-growth forests. These stands are variable in age and successional status and in their relative value for use as deer habitat, for timber production, and for other uses.

From the standpoint of timber production, clearcutting is the optimum silvicultural system for regenerating old-growth stands in southeast Alaska. Removal of the old-growth and subsequent development of even-aged stands, however, can greatly alter deer habitat by reducing the future supply of available forage. Quantitative area-by-area information is needed on the habitat requirements of deer and the ability of various forest stands to supply those requirements under natural conditions and under management. Only then will land managers be able to satisfactorily weigh the effects that timber management or other resource developments will have on deer populations.

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Ecology of Deer Range in Alaska

by

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Introduction

In Alaska, Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) occupy a habitat characterized by highly dissected islands and adjacent coastal mainland areas with wide topographic variations and a strong maritime climatic influence. Mountains often rise directly from the sea and support dense coniferous rain forests to elevations of 450 to 750 meters, depending on proximity to glaciers, icefields, the open sea, and site factors, such as soil conditions and exposure. Where level or gradually sloping land occurs adjacent to the beach or on benches on the lower slopes, drainage is generally impeded through the development of hardpan soil layers and the accumulation of organic matter in sphagnum bogs or muskegs. On sites where tree growth is absent or greatly restricted, numerous openings of varying sizes are provided in the otherwise fairly uniform forest cover below timberline.

Although light penetration to the forest floor is greatly restricted by the tree canopy in old-growth timber, windfall of overage trees creates frequent breaks in the canopy. Understory vegetation, therefore, varies considerably in density and diversity, largely in response to available light. Low-growing vegetation also occurs in greater density in response to increased light on other areas, such as those adjacent to streams, rock outcrops, and shorelines, in avalanche zones, where landslides have occurred, in insect-killed timber, and blowdowns, and where the forest canopy opens near the timberline. Above timberline, lush growths of alpine vegetation occur in response to the abundance of light and moisture.

The following generalizations about the ecology of deer range in Alaska are derived mainly from work within the historical range of deer in southeast Alaska [Klein, 1963 and 1965], however, the habitat characteristics in the Yakutat, Prince William Sound, and Kodiak Island areas, where deer have been introduced, are also similar.

The Climatic Effect

Although all deer range in Alaska is under strong maritime climatic influences, there are, nevertheless, pronounced local variations in temperature, rainfall, and

winter snow depth which markedly affect vegetative composition and plant growth and, in turn, the abundance, quality and availability of deer forage. One of the most apparent clines in deer habitat in southeast Alaska is between the coastal mainland and adjacent islands, which normally experience warm summers and cold winters with heavy snowfall, and the outermost islands on the western edge of the archipelago, which have cool summers and mild winters with light snowfall.

Comparisons of deer habitat on Woronkofski Island, close to the mainland, and Coronation Island on the outer coast and under a stronger maritime climatic influence, show pronounced differences in plant density and species composition (table 1) [Klein, 1965]. Both plant density and species diversity were greater in all four major habitat types on Woronkofski than on Coronation Island. Although climatic differences and proximity to post glacial avenues of plant dispersal are, to a large extent, responsible for these differences. The grazing pressure of deer on the vegetation has also been a major influencing factor. Similarly, the diversity of flora also decreases from south to north. Under the more severe winter conditions close to the mainland, deer are periodically subjected to heavy winter snows which protect the vegetation from excessive winter grazing by deer and limit deer populations through winter starvation. As a consequence, deer densities, except for infrequent irruptions during sequences of mild winters, are on the mean considerably lower on the mainland and adjacent islands than on those islands on the western edge of the archipelago. Additionally, periods of very low deer densities, following sequences of severe winters, allow for recovery of preferred forage species. On Coronation Island, the

Table 1. Comparison of plant density and species abundance in various vegetation types on Woronkofski and Coronation Islands

Item	Forest		Muskeg		Subalpine		Alpine	
	W[1/]	C[1/]	W	C	W	C	W	C
Number of transects	10	10	3	6	6	4	7	3
Plant Density:								
Mean number per interception	109.6	53.7	296.7	241.8	200.8	203.8	294.5	274.7
Standard error	19.48	13.49	18.41	12.88	22.16	33.78	9.47	40.18
"t"	2.36		2.44		0.07		0.48	
Level of significance	0.05		0.05		2/		2/	
Species Abundance:								
Total species (all transects)	133	82	66	114	103	67	145	69
Mean number per transect	13.3	8.2	22.0	19.0	17.2	16.8	20.7	23.0
Standard error	1.10	0.92	0.58	0.63	1.56	2.69	2.03	3.79
"t"	22.29		3.50		0.13		0.54	
Level of significance	0.001		0.01		2/		2/	

Source: Klein, 1965.
1/ W = Woronkofski Island, and C = Coronation Island.
2/ Not significant at the 0.05 level.

more constant grazing pressure by deer resulted in the virtual elimination of several of the more preferred forage species and a substantial reduction in the frequencies of many other plant species used by deer.

It should be emphasized that these observations are not directly applicable to all deer range in Alaska without taking into consideration the differences which exist in the influences of predation on deer density, in the extent of altitudinal and topographic variations, in the size of islands, and in the local climatic variations. Consequently, wolves may hold down deer numbers after a sequence of severe winters so that response to mild winters may be delayed, as was the recent case on Mitkof and Kupreanof Islands. The maritime climate may penetrate well into the archipelago, as on the Cleveland Peninsula, and the continental climate may result in excessive annual snow depths for deer, as adjacent to Lynn Canal. Wide altitudinal variation may moderate the effect of winter grazing pressure, as on the southwest coast of Baranof Island. And, on small islands with limited habitat diversity, there is less opportunity for dispersal of deer as a factor in moderating the effects of deer on the vegetation.

Winter versus Summer Range

Most Alaskan deer habitat is characterized by wide altitudinal range with extensive areas of high-quality alpine vegetation above the treeline. But, as a consequence of heavy winter snows at higher elevations, the available range area is greatly reduced in winter, compared with summer. So, the quality of available forage, measured in digestibility and the complex of nutrients present, is also more greatly depressed in winter than in summer. This results from the cessation of growth in plants in winter and the associated loss of leaves in most shrubs and perennial herbs, as well as the restriction of deer mainly to forested areas where forest floor vegetation is subject to limited light during the growing season.

Deer have adapted to this situation by synchronizing their annual physiological cycle with that of forage availability and quality. The highest physiological demands, including lactation and growth of young animals and antlers, occur in spring and early in summer when protein and other nutrients needed to meet these growth requirements are most favorably balanced in forage. Growth priorities in most age classes shift by late in summer from skeletal and muscle tissues to an emphasis on fat deposition which coincides with decreasing protein to carbohydrate ratios in the forage. In winter, deer undergo relative growth dormancy, and energy from stored fat and dietary intake becomes the primary nutrient required for body maintenance and activity. Although the seasonal carryover in physiological condition of deer makes seasonal range components interdependent, spring and summer range are more directly related to growth and body size of deer, and winter range has its primary influence on over-winter survival and population regulation. This adaptation of the annual physiological cycle of deer to the seasonal variability in quality and abundance of available forage is also shared by all other northern ungulates. It is perhaps most pronounced in the caribou and reindeer (*Rangifer tarandus*) and muskox (*Ovibos moschatus*). In southeast Alaska, protein levels in optimum summer deer forage exceed 20 percent, but in winter comparable values are seldom more than 8 percent [Klein, 1956 and 1965]. Similarly, lichens, which are normally the primary winter food of caribou and reindeer, are high in available energy in the form of starch, but protein levels are generally in the 2- to 3-percent range. In contrast, new growth arctic and alpine tundra vegetation used by caribou and reindeer in summer commonly exceeds 25 percent protein [Klein, 1970a].

Factors Governing Forage Quality

Light--Photosynthesis, in comparison with other photochemical reactions, such as chlorophyll synthesis, phototropism, and photoperiodism, requires relatively high light intensities. Optimum light intensities for photosynthesis are generally in the 10,000-20,000 lux range. Within coniferous forests with closed canopies, light reaching the forest floor may be less than 1,000 luxes, even on clear days, in contrast to intensities in excess of 50,000 luxes on open muskeg, alpine, or clearcut areas.

Although light may be adequate but marginal under forest canopies on clear summer days, it may be less than adequate on cloudy days. Shading is therefore an important factor governing growth of plants used by deer within the forest.

Shading eliminates the shorter wavelength components of light which are used most efficiently by the photosynthesizing leaf. Another effect of shading is in the reduction of air temperatures within closed canopy forests on must summer days. This can have a pronounced effect on photosynthetic rate and plant growth under the cool summer conditions of southeast Alaska. Rates of photosynthesis and plant growth decrease in temperate-region plants with any decrease in air temperature below 21° C [Popp, 1926].

Forest-adapted plants, such as dwarf dogwood (*Cornus canadensis*), trailing bramble (*Rubus pedatus*), and sword fern (*Polystichum munitum*), have a high tolerance for cool temperatures and low light intensities during the growth period. But, this adaptation is gained at the cost of a reduced growth rate and results in their low relative nutritive value for grazing animals. Comparisons of nutritive values of forest floor vegetation in summer with open-grown vegetation in alpine and muskeg vegetation [Klein, 1963].

In the alpine habitat, plants are adapted to the wide temperature extremes that often occur between day and night. Nighttime temperatures may go below freezing during summer without killing the growing plant tissues of most alpine plants. Also, the low-growth form of alpine plants enables them to take advantage of the microclimatic effect close to the ground surface where heating from solar radiation is most pronounced. In addition, absorption of solar energy by green leaves in summer in temperate regions can raise leaf temperatures by as much as 6°-9° C above ambient air temperatures, thus affecting thermal reactions in the leaf [Curtis, 1936]. During the summer growth period, the average daily period of solar radiation in alpine areas exceeds that at sealevel in adjacent areas because of the lower angle the horizon presents to alpine areas.

The long day length during summer and the short cool nights at high latitudes result in long periods of photosynthesis and brief periods of catabolic respiration among alpine plant forms. The long photosynthetic period has been shown to be responsible for higher nitrogen levels in arctic and subarctic vegetation in contrast with levels of similar plants grown in temperate regions [Kolderup, 1975]. Alpine vegetation has also been shown to have higher forage quality than similar vegetation grown in adjacent lowlands [Johnson, Bezeau, and Smoliak, 1968]. The brief cool nights in the arctic and in high-latitude alpine areas (when photosynthesis is not taking place) result in less loss of soluble carbohydrates through catabolic respiration than in plants further south where nights are longer, thus accounting for higher quality forage for herbivores grazing at night or early in morning hours [Klein, 1970b].

Topographic variation--Any variation in exposure, altitude, and slope from a flat plain at sealevel will alter plant phenological progression. In southeast Alaska on steep south-facing slopes, snowmelt in spring and progression of plant growth are advanced 2-3 weeks or more over level areas. An even wider gap exists between north-

and south-facing slopes. Extremely steep slopes shed snow and south-facing slopes receive the full force of the relatively warm southeast storms late in winter and spring. This results in premature snowmelts, even at higher elevations. In addition, dark-colored rock ledges and outcrops absorb solar energy and reradiate it to immediately surrounding areas, which leads to early snowmelt and initiation of growth of plants in rock crevices and adjacent to outcrops, even before the snow has left other nearby areas.

Except for the slope-exposure effect previously discussed, increases in altitude are accompanied by corresponding delays in plant phenological progression during spring and early in summer. Hopkins' bioclimatic law predicts a 3- to 4-day delay in the progression of vegetative growth in spring and early in summer for each 100- to 130-meter increase in altitude [Hopkins, 1920]. In our deer investigations in southeast Alaska, we found that deer take advantage of this altitudinal progression of plant growth by seeking the highest quality early-growth vegetation which closely follows the receding snowline up the mountain slopes. We were able to construct a model of this relationship through the collection and analysis of samples from a key summer forage species (*Fauria crista-galli*) which was present from sealevel into the alpine areas. This relationship of forage quality to season and altitude is shown in figure 1.

Photosynthesizing plant tissues early in the physiological stages of growth have higher nutritional values than in their later growth stages. It follows that the greater the topographic variation in the form of altitude, slope, and exposure within deer habitat, the longer will be the period during the growing season when forage of high quality will be available for selective grazing by deer capable of ranging over the topographic extremes. This appears to be the single, most important factor accounting for differences in growth rates and body sizes of deer in Alaska. Where extensive alpine areas exist in southeast Alaska, deer move into these areas as soon as snow leaves southern exposures and new vegetation emerges. As the season progresses, deer progressively move from site to site as additional areas become snow-free and growth of the vegetation is initiated.

Plant responses to grazing--There is increasing evidence that plants, rather than being passive recipients of the abuses of herbivores to their tissues, have evolved defense mechanisms against herbivory. These include chemical substances that are toxic or that interfere with digestion and have apparently evolved differentially in relationship to whether the plant tissues involved are ephemerally or persistently vulnerable to grazing by herbivores [Rhoades and Cates, 1976]. We have shown that shrubs used by snowshoe hares (*Lepus americanus*) in interior Alaska in winter appear to have evolved both chemical and morphological defenses to grazing in relation to their vulnerability as a result of their stage of growth and the depth of snow [Klein, 1977]. Dimock and others [1976] have shown that the genotype of Douglas-fir affected feeding selection for foliage by both black-tailed deer and snowshoe hares, and they suggest that resistance to grazing in plants is strongly inherited and is chiefly additive. Haukioja and Niemela [1977] in Finland found that plant responses to grazing of birch by insect larvae have resulted in retarded growth of the larvae that continued to feed on damaged plants.

Deer in southeast Alaska have pronounced effects on certain forage species through their grazing activity, and it is likely that this selective pressure has resulted in the evolution of defenses against deer by the flora present. There are indications of this in the fact that tops of windthrown redcedar and yellowcedar (*Thuja plicata* and *Chamaecyparis nootkatensis*) are generally browsed clean by deer in winter and that new reproductions of these species within reach of deer are less highly preferred. Skunk cabbage (*Lysichiton americanum*) is eagerly sought by deer when it is beginning growth in spring, but it is generally not touched after the leaves unfurl, which coincides with the increase of oxalates in the leaf tissues.

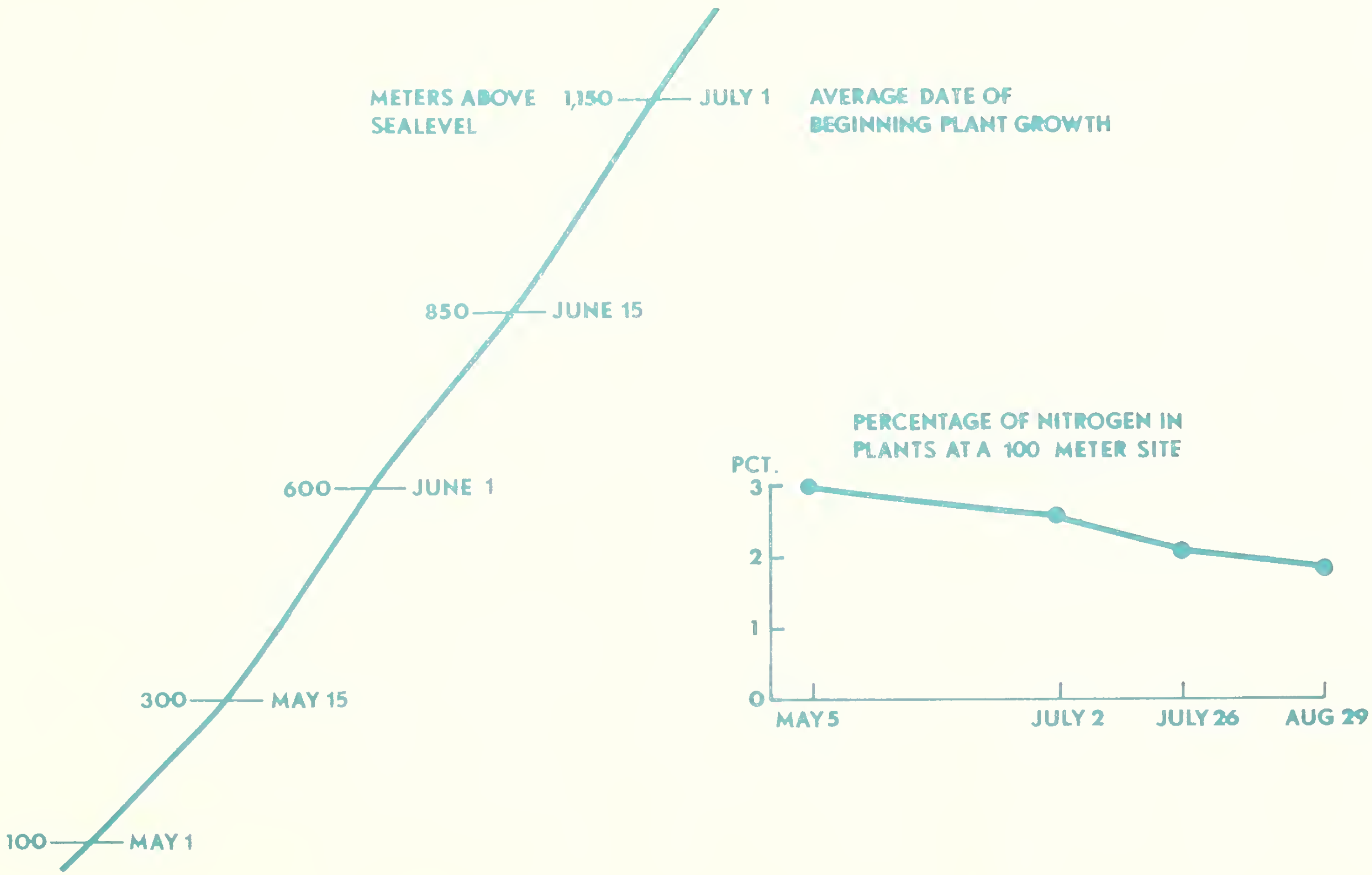

Figure 1--Deer lettuce, *Fauria crista-galli*: Beginning plant growth by elevation and time of year; nitrogen content of plants by time of year on Mitkof Island

The leaves of devilsclub (*Oplopanax horridus*) are commonly eaten by deer when they are emerging in spring, but the stems and maturing leaves are protected by dense spines which undoubtedly inhibit grazing by deer.

There is obviously a need for investigation into the role of chemical and morphological defenses of plants against herbivory by deer in southeast Alaska. Indications are that such evolved defenses by plants are directly related to the edaphic conditions which accompany plant growth. Therefore, it can be expected that forestry practices which alter edaphic conditions will influence plant defense processes and therefore affect the use of plants by deer.

Summary

Deer show characteristic physiological responses to variations in range quality. These responses may be considered variations from the optimum. They are brought about through limitations in the quality and quantity of forage consumed below those levels required for maintenance and optimum growth and development of deer. The nature of the annual physiological regime of deer, including rapid summer growth rates and relative winter dormancy of deer in relation to seasonal variations in forage quality, point to the summer period as the most critical period influencing growth, development, and the attainment of ultimate body sizes.

The factors of the environment responsible for the differences in quality and quantity of available forage on deer range in Alaska are mainly differences in the degree of altitudinal and topographic variation and in the associated relative proportions of alpine and subalpine areas. Secondarily, the regional climatic differences, including depth and duration of winter snows, and the presence or absence of predation are important range-related factors. Other factors, such as the quality and duration of light in high-latitude alpine areas, influence forage quality as well as the responses of plants to herbivory through the development of defenses against grazers.

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The Black-tailed Deer and Forest Succession in the Pacific Northwest

by

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Introduction

The black-tailed deer of the Pacific Northwest is the Columbian race (*Odocoileus hemionus columbianus*). We are considering it here in those portions of its range extending from northern California to southern British Columbia, a region of mild climate.

Historically, the Douglas-fir forests, which extended over much of this zone, consisted of even-aged stands that became established following summer-fall wildfires. Exploitation of these forests, beginning about a century ago, was accompanied by more frequent accidental fires. Modern forestry management has controlled wildfires, on the whole, but adopted the pattern of blockcutting and uniform regeneration, which again results in a forest of even-aged stands, albeit shorter lived than their predecessors because of early harvesting.

The mountains which comprise the eastern range of the black-tailed deer provide summer deer forage but are snowcovered in winter. Deer of migratory habits move upward in spring and downward in fall to spend winter below the zone of normal or frequent accumulations of snow. There, in the lowlands, are other populations which remain as year-round residents. The frequent lack of snow, or its short duration on winter ranges in this region, distinguishes these deer habitats from those farther north, where winter snow accumulates even at lower elevations.

With increasing human populations, the economic importance of the deer as a game species and an object of amenity has steadily increased. As forest management has become more intense, damage by deer to forest regeneration and apparent effects of forestry practices on deer populations have also increased. The growing potential for conflict between two valuable regional resources--deer and timber--and the possibilities of alleviation, through the development of integrated management planning,

constitute the theme of this report. In it, we endeavor to update the earlier reviews of the ecology and management of black-tailed deer, including those of Cowan [1956], Brown [1961], and Taber [1961].

Deer-Forest Relationships

Ecological variations within the study region--Deer-forest relationships are affected by differences in forest type, deer population, and seasonality. The forest types of this region, as classified and described by Franklin and Dyrness [1973], include the Sitka spruce, western hemlock, Pacific silver fir, mixed conifer, mixed evergreen, Shasta red fir, and the coast redwood zones.

The occurrence, composition, and productivity of these forest types are largely governed by two major environmental gradients--temperature and precipitation (fig. 1). Productivity and rate of succession are generally greater with increasing length of growing season and availability of soil moisture. Since deer are influenced by plant succession, the response time and magnitude of deer population response to clearcutting or burning correspondingly vary along these gradients. Similarly, the potential for damage to conifer regeneration by deer varies, being greater where growing conditions for conifers are less favorable. Thus, although similarities in timber management and patterns of plant response widely prevail throughout this region, differences in speed of succession cause differences in deer population response.

Elements of the deer-forest conflict--The even-aged forests of this region, when fully stocked, form a virtually complete crown closure within 2 or 3 decades. Very little plant growth occurs in the dense shade of the forest floor. Deer, which must obtain their forage within 4 feet of the ground, may shelter in such a forest, but they must feed elsewhere. Places where there is sufficient light for the production of understory vegetation include the "overmature" forest with its openings caused by the falling of limbs and trees, the forest edge, and areas cleared of trees, such as burns and clearcuts; such places produce forage suitable for deer. With intensive forest management, the "overmature" forest disappears, the patchy clumping of natural regeneration is evenly replaced by planted seedlings, and the addition of nitrogen hastens foliar growth and crown closure. At the same time, fertilized containerized seedlings are nutritionally attractive to deer, particularly if alternative food choices have been reduced by herbicide treatment.

Impacts of forest management patterns on deer populations--Removal of trees, whether by thinning or clearcutting, encourages understory plants which constitute potential deer forage. The degree of use that a given foraging area will receive is dependent upon deer density, individual home range size, and quality of the habitat as related to degree of interspersion, species composition, and adequacy of escape and thermal cover.

For an animal to be attracted to a clearcutting, that animal must be aware that the cutting exists. In this respect home range size is important. Generally speaking, black-tailed deer have relatively small home ranges. Average annual home range sizes of resident populations have been reported as about 130-260 hectares (320-640 acres) for black-tailed deer in the California chaparral [Dasmann and Taber, 1956] and 70-100 hectares (170-250 acres) in the Tillamook Burn area of northwestern Oregon [Miller, 1970], with bucks tending to have larger home ranges than does. Migratory populations have two such seasonal home ranges connected by migratory pathways.

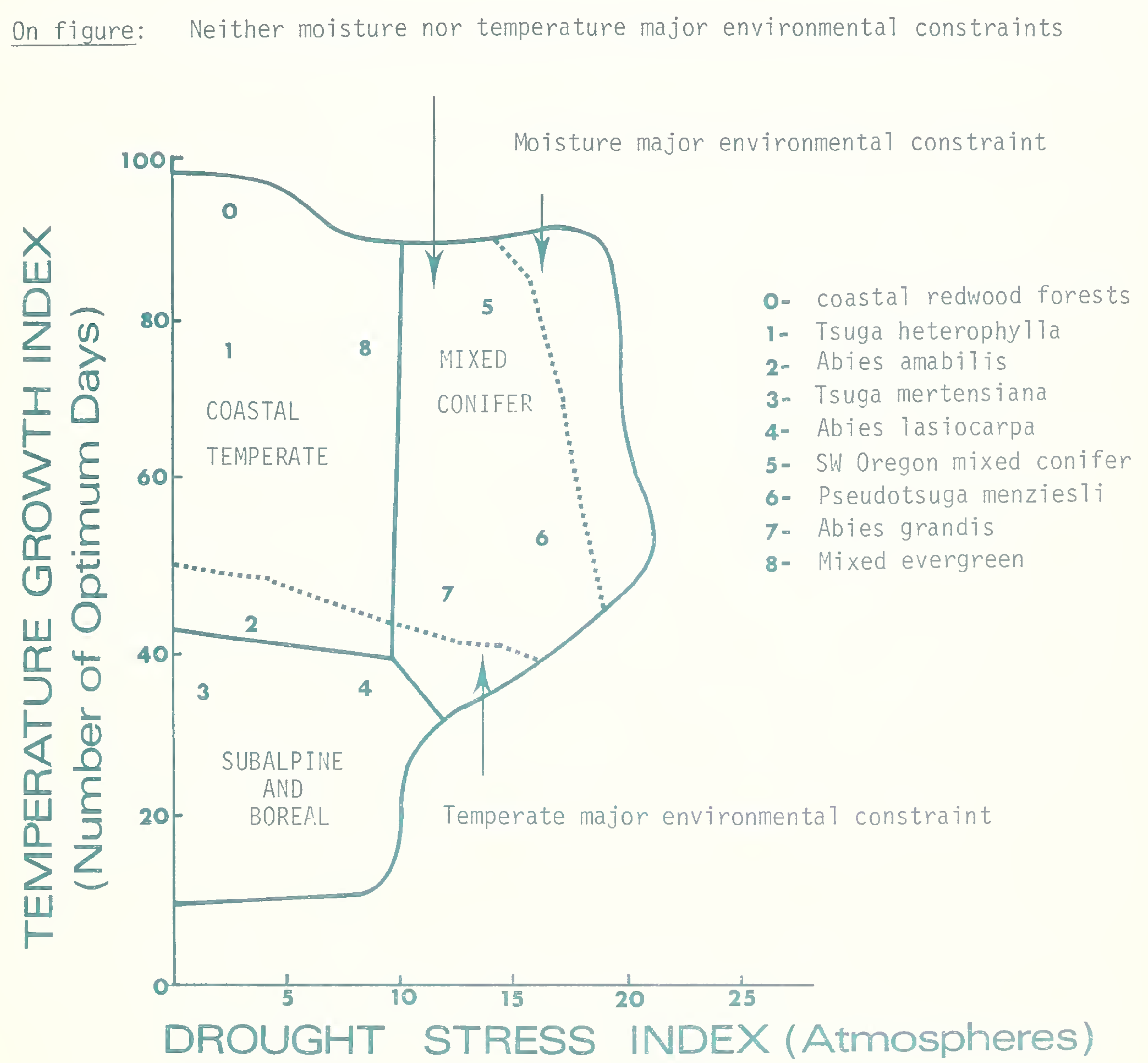

Figure 1--Distribution of some of the major forest zones within an environmental field based on moisture (maximum plant moisture stress during the dry season) and temperature (optimum growth days computed by the procedure of Cleary and Waring [1969]) [*Source: Franklin and Dyrness* [1973], *with modifications*]

Assuming an average seasonal home range of about 80 hectares (diameter 1 kilometer), a deer from about 1 kilometer distant would be expected to be aware of a new clearcut or burn. Following this reasoning, a 10-hectare clearcut in a mature forest, where deer density is 4 per square kilometer, will attract about 4 deer; browsing pressure will potentially be about 1 deer per 2.5 hectares. However, a 40-hectare clearcut, 4 times as large, would also attract about 4 deer, so its potential browsing pressure would be only about 1 deer per 10 hectares. Thus, deer density, home range size, and clearing size (and proximity to other clearings) interact in determining the potential degree of use of a given cutting or burn area.

In addition to these considerations, the actual degree of use of a given cutting or burn area will depend upon its attractiveness to deer, which is affected by topography, disturbance factors, and age of the cutting or burn interacting to affect the species composition and forage production of a given site. The relative amount of forage available is a major factor affecting deer selection between particular plant communities [Miller, 1968]. In the western hemlock zone of western Washington, deer use commonly corresponds with total available forage production, and use peaks at about 15 to 25 years following clearcutting [Brown, 1961]. In the coastal redwood areas, this peak comes earlier [Browning and Lauppe, 1964]. In either case, the subsequent decline of forage production is caused by the increasing shade cast by the young conifer canopy. The degree of interspersion of forage, water, and cover is also important, and for this reason, small openings are much preferred over large openings.

Snow accumulation is a critical factor affecting deer use of vegetative communities in winter. The upper elevational limit for migratory populations is set by snow depth, and as little as 3 or 4 inches of new snowfall reportedly drives deer to a lower level [McCullough, 1964]. On Vancouver Island, Jones [1974] found that deer use of clearcuts was nearly eliminated by deep snow accumulations and that mature timber, where snow depth was less, was a critical element of deer winter range. Second-growth forest was not satisfactory because of the lack of available forage.

Elevation, exposure, and slope affect the depth and persistence of snow, the thermal regime for deer, and the phenology of the vegetation. Thus, topographic variations create certain favorable areas where deer tend to congregate. In winter, these are typically moderately sloping southerly exposures at lower elevations. These are particularly preferred when the first flush of spring growth appears, an event which occurs earlier on these sites than on others. Higher elevations or northerly exposures are more favored in summer.

The conventional model of black-tailed deer population response to clearcutting, proposed by Lawrence [1969], was illustrated by Brown [1961] for the western hemlock zone of western Washington (fig. 2). The concept is that deer populations, originally with a density of about 4 deer per square kilometer (about 10 per square mile), increase to a density of as many as 25 deer per square kilometer (65 per square mile) by about 20 years following logging, in response to increased forage production. They then gradually decrease to very low numbers, such as 1 or 2 deer per square kilometer (2 to 5 per square mile), with canopy closure of the conifer second growth. Failure of conifers to regenerate permits the shrub layer to endure and so enhances and prolongs the peak of deer density. The concept further assumes that clearcutting is conducted in a patchwork pattern and that, although some local deer populations are declining, others are increasing. The net affect is a greatly enhanced carrying capacity of the landscape as a whole for black-tailed deer.

Although such a model is intuitively appealing, its simplicity masks many of the relationships critically affecting deer population response to timber management and forest succession. The model is most appropriate for clearcutting in mature forest at low elevations. With intensifying timber harvest, old-growth stands at low elevations are becoming rare and dense second-growth stands common, although clearcutting of

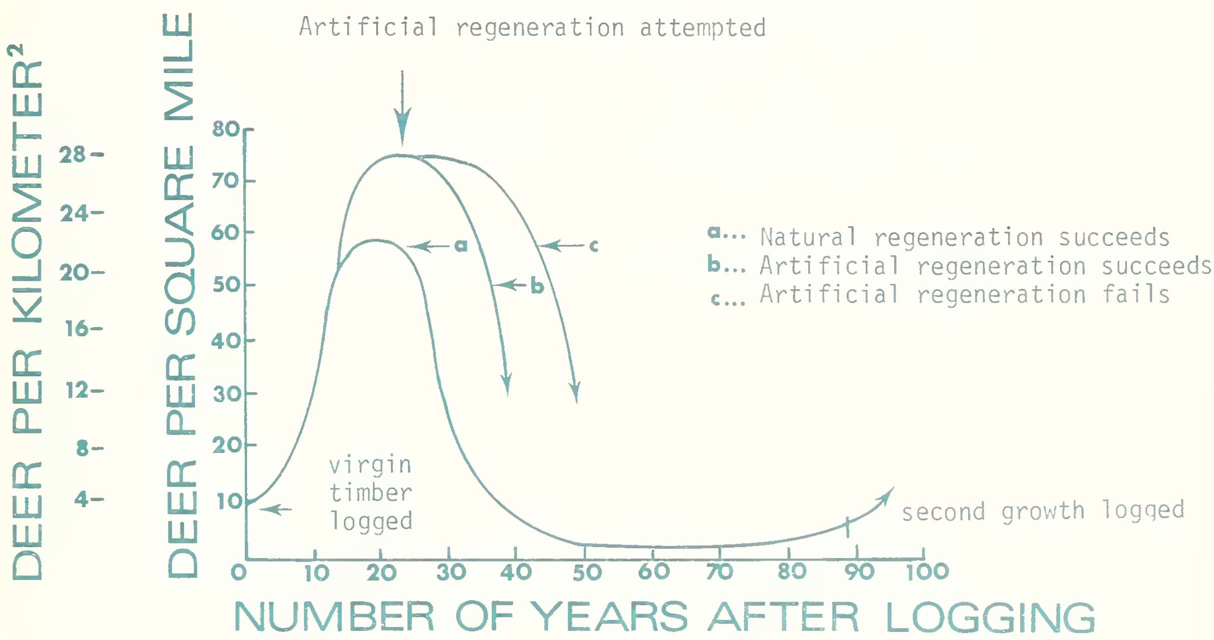

Figure 2--Brown's [1961] model of the effect of forest succession and success or failure of regeneration of coniferous forest species on a hypothetical deer population (western hemlock zone, western Washington)

mature forests at higher elevations (for example, Pacific silver fir zone in western Washington) is increasing. For migratory deer, this means an enhancement of summer forage resources but also a decline in available winter forage. Since migratory populations are not limited by their summer resources in such a situation, an increase of summer forage following clearcutting will not be accompanied by the increase in deer population predicted by the model. Furthermore, severe winter competition with resident deer should be expected to limit resident deer population levels with the consequent result that, even if winter forage availability were increased, resident deer populations might not show the response predicted by this model. Competition for forage on deer winter ranges can deplete preferred foods and result in heavy browsing damage to conifer seedlings.

As with other herbivores in temperate regions, deer tend to feed most heavily when forage is most abundant and nutritious--the spring and summer--and store fat, which is drawn upon in the leaner times of winter. Winter foods, though nutritionally inferior to summer foods, are nevertheless important, as shown by the rapid onset of starvation when a few inches of snow covers the evergreen trailing blackberry, a primary winter food plant.

Food habits--Food habits of the black-tailed deer vary geographically (table 1), but several species, such as Douglas-fir, salal, huckleberry, and fireweed, are widely used to some degree when available. Consumption of herbaceous material varies seasonally, but browse consistently provides the major portion of the diet (fig. 3).

In spring, grasses, sedges, and early greening forbs provide a nutritious source of forage. As other herbaceous species become available and winter-dormant shrubs grow leaves, the diet becomes more diverse. The range of food items is greatest in summer and begins declining in the fall.

In winter, herbaceous biomass is much reduced in abundance and quality, many shrubs drop their leaves, and occasional snows reduce forage availability. Shelter from exposure is afforded by a young regenerating forest, but this has little deer forage in the understory.

Although deer are known to prefer plants which are esoecially nutritious, the nutrient content of plants is not always correlated with their palatability. The specific basis upon which a deer selects a bite of forage has not been positively identified. There seems to be a positive correlation between palatability and digestibility or, perhaps more precisely, a negative correlation between palatability and volatile oils that inhibit the growth of rumen micro-organisms [Longhurst and others, 1968; Oh and others, 1968; and Radwan and Crouch, 1974]. Although olfaction is the primary sense used by deer to discern the plants they prefer [Longhurst and others, 1968], taste may also be important [Crawford and Church, 1971]. Given our present state of knowledge, it seems best for deer to have a variety of plant species choices, since a mixed diet can successfully include small amounts of the less palatable forage species.

Nutrient quality of available forage varies seasonally, being lowest in winter (table 2). Einarsen [1946b] felt protein was an especially critical nutrient limiting black-tailed deer (Dasmann and Dasmann [1963] also believed the same) and that a minimum protein content of about 5 percent was necessary for winter maintenance. A fair figure for daily requirement of nutritious forage is about 1.7 kilograms of air-dry forage per 50 kilograms of body weight (3.3 pounds per 100 pounds), or about 3.7 kilograms of green forage for an animal weighing 60 kilograms (8 pounds forage for a 130-pound deer) [Palmer, 1944; Cowan, 1956]. Actual consumption, however, should be expected to vary with the palatability of available forage--consumption being greater during summer and less during winter. Presumably the more nutritious

Table 1. Major forage species in the diets of black-tailed deer

Species	British Columbia[1/]	western Washington[2/]	western Oregon[3/]	northern California[4/]
TREES				
Acer circinatum		X	X	
Acer macrophyllum	X		X	
Alnus rubra	X	X	X	
Arbutus menziesii	X			X
Lithocarpus densiflora				X
Prunus emarginata			X	X
Pseudotsuga menziesii	X	X	X	X
Quercus chrysolepis				X
Sequoia sempervirens				X
Thuja plicata	X	X		
Tsuga heterophylla		X		
SHRUBS				
Baccharis pilularis				X
Berberis nervosa	X			
Ceanothus sanguineus			X	
Ceanothus spp.				X
Cenaothus velutinus				X
Cornus nuttalli	X			
Corylus cornuta			X	
Gaultheria shallon	X	X	X	X
Holodiscus discolor			X	
Rhamnus purchiama			X	
Ribes snaguineum			X	
Rosa gymnocarpa			X	
Rubus leucodermis	X			
Rubus macropetalus		X	X	
Rubus parviflorus	X		X	
Rubus spectabilis		X	X	
Salix spp.	X	X	X	
Sambucus racemosa	X		X	
Spirea spp.	X			
Vaccinium ovatum				X
Vaccinium parvifolium	X		X	
Vaccinium spp.		X		
HERBS				
grasses	X	X	X	X
sedges	X		X	
Agoseris spp.		X		
Anaphalis margaritacea		X	X	
Blechnum spicant		X		
Epilobium angustifolium	X	X	X	X
Equisetum spp.	X	X		X
Hypochaeris radicata	X			
Lotus spp.			X	X
Oxalis spp.		X		
Phacelia spp.				X

Table 1. Major forage species in the diets of black-tailed deer (continued)

Species	British Columbia1/	western Washington2/	western Oregon3/	northern California4/
HERBS (cont.)				
Plantago spp.		X		
Polystichum spp.			X	
Pteridium aquilinum	X		X	
Trifolium spp.		X		
Vancouveria planipetala				X
MOSS and LICHENS				
Usnea barbata	X			

1/ western hemlock and Sitka spruce zones, Cowan [1945, 1956]
2/ western hemlock zone, Brown [1961]
3/ western hemlock zone, Einarsen [1946a], Cowan [1956], Crouch [1968]
4/ coast redwood forest, Browning and Lauppe [1964]

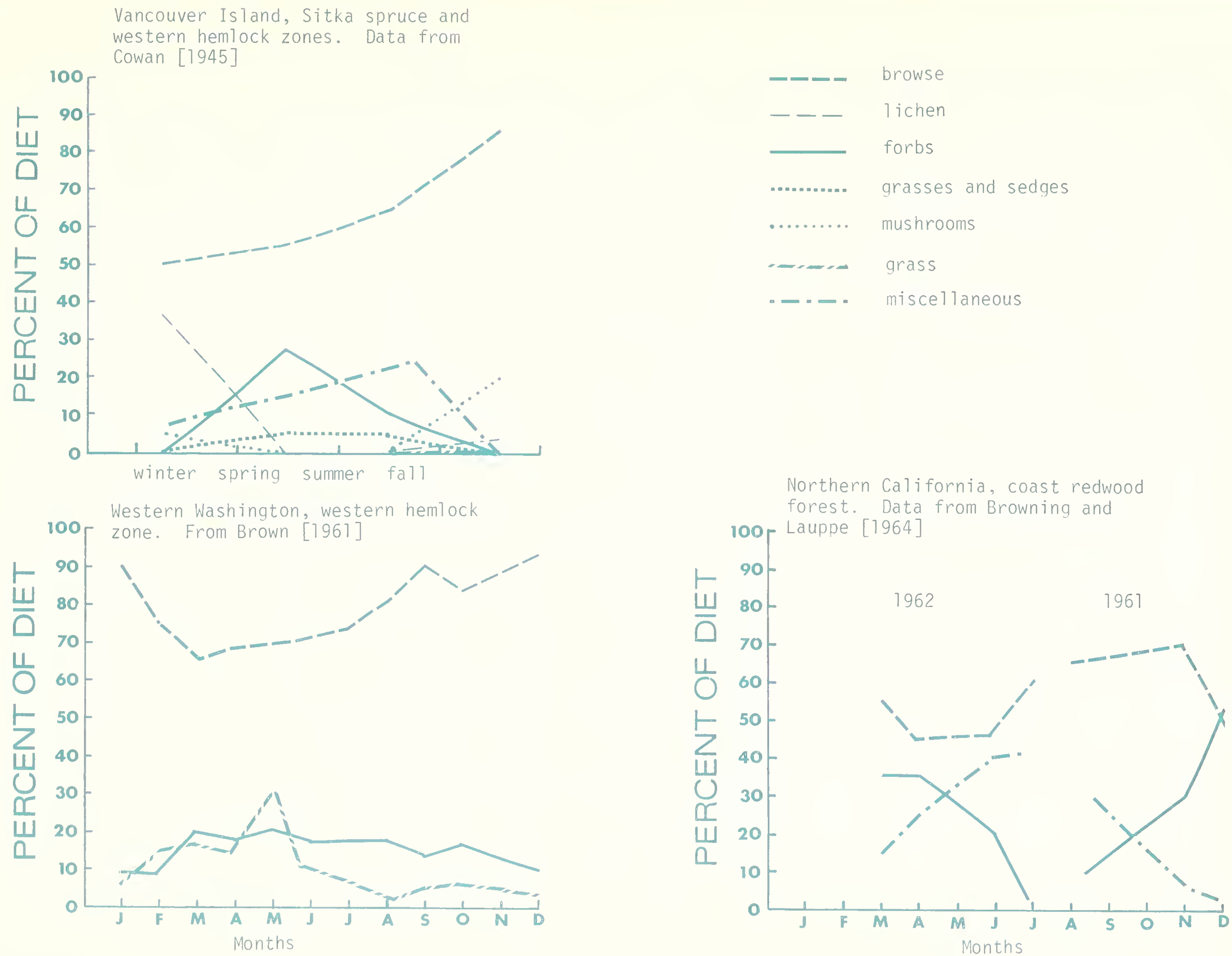

Figure 3--Changes in composition of black-tailed deer diets in three different geographic regions

Table 2. Percentage crude protein content of deer forages, Tillamook Burn area, northwestern Oregon. From Einarsen [1946a].

Species	June	December
vine maple (*Acer circinatum*)	12.83	5.31
red alder (*Alnus rubra*)	11.48	7.49
salmonberry (*Rubus spectabilis*)	9.42	7.32
red elderberry (*Sambucus racemosa*)	27.75	9.71
thimbleberry (*Rubus parviflorus*)	8.58	4.25
fireweed (*Epilobium angustifolium*)	17.69	___*

*not available in winter

foods, being more readily digestible, pass more rapidly through the digestive tract, allowing a greater total daily intake.

Response of forage plants to fire and logging--Three major effects of disturbance by clearcutting or fire on deer forage plants in forests of the Pacific Northwest are a change in plant species composition, an increase in forage production, and changes in nutrient quality [Taber, 1973]. In the mature forest, understory vegetation is suppressed by shading and is low in nutrient quality. Removal of the dense conifer canopy encourages the growth of understory plants. When this removal is by clearcutting, scarification of the ground surface enhances the opportunity for invading species to become established. This increases the variety of species available as deer forage. When fire is involved, ash temporarily enhances the soil fertility of the site, and it also eliminates conifer seedlings already established in the mature forest, thereby temporarily delaying reestablishment of conifer domination.

Although the composition of the plant community growing within a clearcut is strongly dependent upon the understory composition of the forest before disturbance, it is also affected by any soil disturbance during logging, methods of slash disposal, fire, and herbicide treatment. Generally, the number of species present in the community is greatest during the period from 5 to 20 years following disturbance (tables 3 and 4). Vascular understory biomass tends to peak slightly later (table 4). Although summer deer forage availability is generally much greater in clearcuts than in old-growth forest (tables 4 and 5), this relationship does not necessarily hold true during winter (tables 5 and 6). Winter forage is often more abundant in old-growth stands than in adjacent clearcuts, particularly when snow accumulations limit forage availability [Jones, 1974].

Table 3. Richness (number of species), evenness [Pielou, 1966], and diversity [Brillouin, 1962] for five different-aged Douglas-fir/salal stands (western hemlock zone, western Washington); from Long [1977].

Item	Stand Age (years)				
	5	22	30	42	73
Richness	41	19	31	24	23
Evenness	0.70	0.51	0.55	0.55	0.66
Diversity	3.76	2.27	2.78	2.58	3.17

Table 4. Richness (number of species) and aboveground biomass (kilograms per hectare, oven-dried) of vascular understory species for eight different-aged western hemlock/ovalleaf huckleberry stands (Pacific silver fir zone, western Washington). Data from Long [1976].

Item	Stand Age (years)							
	1	3	7	17	25	46	250	550
Richness	9	14	16	15	12	13	15	10
Total aboveground biomass	289	1214	1676	1854	4238	181	421	442
Total deer forage	255	898	1524	1389	4162	166	396	392
Total deer browse	218	895	964	1365	4162	166	396	371

Table 5. Wet weights in kilograms per hectare (pounds per acre in parentheses) of available deer forage in mature and clearcut forests (western hemlock zone, Vancouver Island). From Gates [1968].

Season	Mature Forest	Clearcut (age, years)			
		4	9	10	14
Winter	481 (428)	62 (55)	257 (229)		385 (343)
Summer	483 (430)	1065 (948)		1449 (1290)	1251 (1114)

Table 6. Percentage cover (in the fall) of prominent understory species in logged and unlogged habitats (western hemlock and Pacific silver fir zones). From Jones [1974].

Type of habitat	huckle-berry	salal	western redcedar & Alaska-cedar	Douglas-fir	western hemlock	Pacific silver fir
Mature (160+ years)						
high elevation (open crown cover)	60	0	5	0	1	10
low and medium elevation (open crown cover)	25	30	0	0	20	5
low and medium elevation (closed crown cover)	1	0	0	0	25	5
Second-growth (10-20 years)	5	5	10	10	10	0
Clearcut (0-10 years)	1	5	0	1	0	0

Einarsen [1946b] found that opening the forest canopy by fire resulted in increased crude protein content of common deer forages in northwestern Oregon (table 7). But, this same relationship could not be established by Brown [1961] for clear-cutting in western Washington (table 8). Rather, the nutrient quality appears to drop immediately after logging, followed by a rise in the early stages of succession and a steady drop as conifers regain dominance in the second-growth stage (fig. 4). Crude fiber was high in the mature forest, higher immediately after logging, and then low (favorable for digestion) through year 25. The apparent contradiction in these data is probably related to fire [Taber, 1973]. Increase in crude protein content following burning is probably not due to the resultant increase in light, but rather to the fertilizing effects of the ash.

Table 7. Midwinter crude protein content (percent) of deer forage species in four different-aged stands in northwestern Oregon (western hemlock zone). From Einarsen [1946b].

Species	New Burn	3-Month Burn	6-Year Burn	Mature
fireweed	----	12.42	9.90	----
vine maple	3.75	8.39	4.47	3.72
thimbleberry	4.15	11.60	4.73	3.44
blackberry	----	14.91	7.27	----
salmonberry	6.65	13.07	7.17	5.68

Table 8. Crude protein and crude fiber contents in percentage of dry weight in four deer forages available in January on newly logged, 20-25 years past logging, and mature forest (western Washington, western hemlock zone). From Brown [1961].

Species	Mature	Newly Logged	20-25 Years
	--------------------CRUDE PROTEIN--------------------		
trailing blackberry	11.50	10.92	9.94
western redcedar	7.79	-----	5.59
huckleberry	7.47	6.85	7.52
salal	7.35	-----	6.74
	--------------------CRUDE FIBER--------------------		
trailing blackberry	18.80	25.65	14.45
western redcedar	22.23	-----	25.05
huckleberry	38.25	38.83	36.98
salal	22.65	-----	22.65

Figure 4--Crude protein and crude fiber content of trailing blackberry leaves in mature forest and at several ages after logging

[Data are from Brown [1961] in January, western Washington, and Gates [1968] in December, Vancouver Island, as reported by Taber [1973]]

A managerial practice of great potential importance for deer forage production is thinning, whether precommercial thinning or commercial thinning. The general consequence of thinning is that light reaching the forest floor increases, and the potential for the production of understory vegetation increases correspondingly. Since thinning is only now beginning to be widely practiced, its consequences for deer forage have not been quantified, but it may well have profoundly beneficial effects on low-elevation habitats in the future.

On the opposite side are herbicide treatment and forest fertilization. Spraying of herbicides for "brush control" before the planting of conifer seedlings reduced deer forage. Nitrogen fertilization is commonly applied to the young regenerating forest--at perhaps 15 to 20 years of age. It generally causes an increase in foliar growth, which results in more complete canopy closure and more profound shading of the forest floor, with corresponding decline in the understory vegetation.

Influence of deer on forest composition and succession--The most intensively studied deer-plant relationship, by far, is the browsing by deer on seedlings of conifers in the regenerating production forest. Following timber harvest, and perhaps herbicide treatment, the site is generally planted with nursery-grown seedlings of selected genetic stock, often in containers of nutrient-rich soil. Two seasons of seedling damage by deer exist. Winter damage, which is localized, is due essentially to a shortage of available alternate foods. Young Douglas-fir, for example, is not high on the winter forage preference scale, but it is often highly available when little else is. So alternative forage and deer density are important factors in winter damage [Roy, 1960; Crouch, 1966a, 1968; Hines and Land, 1974]. Conifer seedling height is also important, with greatest damage to seedlings of about 30 centimeters [Dimock, 1971; Hines and Land, 1974]; after a seedling reaches 100 centimeters, damage is negligible [Campbell, personal communication].

With the production of new stem growth in the spring, Douglas-fir seedlings rise on the forage preference scale; browsing of the apical bud inhibits height growth and prolongs vulnerability. Where deer use is heavy, plant species little used by deer, such as red alder and bracken fern, overtop the Douglas-fir seedlings early and prolong their vulnerability to browsing damage [Crouch, 1974]. Clipping studies in the Tillamook Burn area of northwestern Oregon revealed that deer use was potentially more damaging to seedlings planted on heavily-shaded than on open sites [Crouch, 1966b].

Various attempts have been made to develop an effective repellent, and at least one formulation is in operational use. Mechanical protection has proven effective on test plots and is beginning to be used operationally. An alternate approach, to grow preferred forage plants (lure crops) in conjunction with damage-prone Douglas-fir plantations, has proven effective on a test-plot scale [Campbell and Evans, personal communication].

Factors affecting palatability of individual Douglas-fir trees may include topographic location, tree age, portion of tree available (tops or bottoms), and degree of shading in environment [Tucker and others, 1976]. Trees in dense clumps are often avoided, in preference to more openly-spaced individuals [Cowan, 1945].

Under moderate, as opposed to heavy, deer use Crouch [1974] found that Douglas-fir was able to outgrow the nonconifers in the Coast Range of western Oregon. Moderate deer use even appeared to benefit Douglas-fir by reducing competition from woody plant species favored by deer.

In general, deer damage to Douglas-fir seedlings appears to be greatest where moisture stress is greatest, growth slow, period of vulnerability relatively long, and ability of seedling to withstand damage is relatively low.

Aside from this concern for seedling damage and its alleviation, our understanding of the effects of black-tailed deer on forest succession is rudimentary. The broader implications of herbivory and potential control of plant communities have not received attention. Scant information on these influences can be gleaned from the literature.

On Vancouver Island, Cowan [1945] noted that deer avoided seed heads of grasses and sedges; and consequently deer feeding had less effect than that of domesticated ungulates on these herbs. He also noted that deer use only infrequently killed shrubs and trees (other than Douglas-fir and western redcedar), but that preferred species such as red huckleberry and flowering current seldom produced fruit under heavy deer utilization pressure. The cumulative effects of heavy deer browsing on the vegetation of Coronation Island, Alaska, resulted in a lowered quantity and quality of forage available to deer there [Klein, 1965]. Such negative feedback loops as these are common in deer-vegetation relationships studied in other North American forest regions [e.g., Beals and others, 1960; Halls and Crawford, 1960].

Positive feedback loops also occur. Habeck [1959] found that on deer winter range in central Wisconsin deer use stimulated vegetative reproduction of important browse species with the consequent increase of browse with increasing deer pressure (we would imagine up to only a certain point, however). That browsing keeps favorite shrubs within the reach of deer is commonly observed on blacktail ranges as well. More subtle influences of deer on forest community relationships have also been reported by Habeck [1960] for deer winter range in northern Wisconsin. There it was found that in white cedar swamps deer use affected soil compaction, peat decomposition, and soil water-retaining capacity in such a way as to create a more mesic environment favorable to the replacement of the cedar community by a more mesic hardwood forest.

Discussion

Management implications--In the range of the black-tailed deer in the Pacific Northwest the value of timber generally far exceeds the values of other natural resources, and consequently logging is the dominant activity affecting deer habitat and deer populations. The interaction of timing, location, juxtaposition of cuttings, and harvest methods employed, however, can result in widely varying effects on deer habitat quality. Therefore, where deer habitat quality is an important consideration in land use and management, certain considerations in silvicultural policy can be taken to enhance or detract from the ability of a landscape to produce deer.

In the present paper we have reviewed some general concepts in black-tailed deer-forest relationships. Management applications for any given land unit, however, must be considered in relation to the unique physical and biotic properties of that unit. The same silvicultural policy applied universally will not yield the same universal results. Particularly important in this respect are considerations of forest type (varying with geographic location and elevation), type of deer populations (resident, migratory, or both), and unique habitat features related to topography. At a finer scale of detail, the land manager should think in terms of *habitat type* [*sensu* Daubenmire, 1968], that is, the kind and amount of vegetation that a given land area is capable of producing. Plant communities differ in species composition, production, and successional relationships, and will respond differently to a given habitat modification.

Winter range is the limiting factor for the vast majority of black-tailed deer populations. This factor is becoming especially critical as the rate of clearcutting is increasing at higher elevations and winter ranges at lower elevations are becoming fully stocked with dense canopies of second-growth coniferous forest. The development of plans to create an integrated pattern of forest management is inhibited by mixed land ownership, desire of managers to liquidate old-growth forest, the difficulty of achieving a desired deer harvest pattern, and the lack of incentive for the private landowner to favor increased deer populations.

A frequently offered solution to the dilemma of decreased carrying capacity of second-growth timber for deer is a shorter rotation time between timber harvests [e.g., Lawrence, 1969]. Shortening the rotation from 80 to 40 years, for example, would supposedly double the long-term carrying capacity for deer; however, this supposition has not been subject to field investigation. It is not known whether the understory, for example, would respond vigorously to such treatment, especially since rapid conifer regeneration would be part of the pattern of such intensive forest management.

The key to black-tailed deer habitat quality in the Pacific Northwest is the degree of interspersion of types of habitat. Many localized areas of land are not suitable for timber production (for example, riparian communities, power or pipeline rights-of-way, roadsides, etc.) and the planning of habitat juxtaposition should not overlook the importance of these. Similarly, local patches of land where site quality for timber production is low may be more valuable in providing cover for deer than in providing timber.

In 1976, Thomas and others introduced a system for establishing elk-deer-forest habitat guidelines to aid land managers in integrating elk and deer habitat requirements with silvicultural policy. A more detailed manual is now in preparation. These guidelines aim toward optimizing the ratios and juxtaposition of forage areas, hiding cover, thermal cover, and water availability in a sustained-yield timber management planning framework. At present they are limited to summer and spring-fall range relationships, and the authors emphasize that winter range habitat modification must be planned on a much more individual basis. These guidelines are worthy of study in the development of a rough conceptual model for forest management for deer in our region.

Almost any forestry practice, in essence, can be a powerful tool for enhancing the quality of habitat for black-tailed deer and an equally powerful tool for reducing the quality of habitat. The difference lies in tailoring the silvicultural policy to the deer habitat management objectives.

Future research needs--The present review has made apparent the need for a better understanding of migratory deer-forest relationships, particularly where migratory populations share winter range with resident herds and where deer generally share range with increasing populations of elk (*Cervus canadensis*). Also important is an understanding of deer relationships to succession following timber harvest of the second-growth Douglas-fir forests which now comprise a large portion of the Pacific Northwest coastal forest zone, and the principal area available for winter deer use. The need for more detailed information, particularly regarding how deer use clearcuts in relation to their size and logging slash, is also important as is a finer resolution of differences related to vegetation zonal associations and habitat types. Evidence of differential mule deer use of clearcut and natural burned areas [Davis, 1977] and Rocky Mountain elk use related to amounts of logging slash [Lyon, 1976] raises questions of the importance of these relationships to black-tailed deer.

An area of deer-forest knowledge that appears to have gone almost wholly unrecognized, moreover, is the influence of deer on their habitat structure and biotic community relationships. Aside from the impact of deer on Douglas-fir seedlings, we know very little about the control function of black-tailed deer on forest vegetation dynamics. As forest management intensifies, and public interests increasingly include the amenity values of forest wildlife, our objectives in deer and deer habitat management will broaden. The need is growing for a deeper understanding of the influence of deer on the biotic community of which it is a part.

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Food Habits of Black-tailed Deer on Forested Habitats in the Pacific Northwest

by

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Introduction

Columbian black-tailed deer (*Odocoileus hemionus columbianus*) occupy conifer forests along the northern Pacific Coast of the continent from north-central California to northern British Columbia, including Vancouver Island. Blacktails also live in chaparral brushlands, oak woodlands, and other habitats but these deer will not be considered here. Also, nutritional aspects of blacktail food habits will not be discussed.

Little has been published on the food and feeding habits of forest dwelling black-tailed deer. Two papers, concerned with Coast Range habitats, contain a large proportion of the information available. Cowan [1945] reported on a comprehensive study conducted on southern Vancouver Island in the late 1930s and Brown [1961] summarized data collected in western Washington in the early 1950s. Since Brown, most studies have related to deer browsing damage to Douglas-fir[1/] in California [Browning and Lauppe, 1963] and in the Tillamook Burn in Oregon [Crouch, 1968; Hines, 1973].

Feeding by blacktails on the Tillamook Burn was the topic of a thesis by Chatelain [1947], and Gates [1968] studied plant succession and foraging on logged areas on southeastern Vancouver Island as a Master's problem. Food habit studies were also a part of several other graduate programs including those completed by Rieck [1952] in Oregon, and Jones [1975] on northern Vancouver Island.

The paucity of data on blacktail feeding habits is puzzling because they comprise virtually all of the deer taken by hunters in the Douglas-fir region, and a sizeable portion of the total harvest in the north Pacific states. For example, almost 44,000

1/ Scientific names of plants are shown in table 3.

blacktails were harvested annually from 1972-76 in Oregon alone [Ebert, 1977]. Obviously, more research is needed to successfully manage forage for blacktails.

In the remainder of this paper I will discuss the forage resources available to blacktails and then summarize feeding patterns based on published information and personal observations.

Forage Resources and Feeding Patterns

Food habits of coastal deer are limited by availability of plants both overall and seasonally, and availability varies greatly with latitude and elevation. The climate of north-coastal forests grades from winter precipitation (mostly rainfall) in northwestern California, to year-round moisture abundance (summer rain and winter snow) in British Columbia. A similar gradient exists from lower to higher elevations.

Plant growth cycles follow usual spring-summer growth and fall-winter dormancy patterns in much of the region. On some California ranges, however, growth of forage species may be regulated by summer dryness, not winter cold [Taber, 1956]. In these areas, succulent forage is abundant during spring, fall, and winter, and relatively scarce in summer.

Forested blacktail ranges are characterized by the presence of plants that are green all year. Evergreen shrubs like salal and Oregon grape and ferns occur as understory cover in timber stands and often make up a sizeable portion of the vegetation present after logging or burning. Other evergreen and semi-evergreen species including tobacco-brush and Pacific blackberry, as well as Douglas-fir and other conifers, also occur after logging or fires. Unless covered by snow these plants offer year-round green feed.

Blacktails are as selective in their choice of plant species, plants within species, and parts of individual plants as other deer. They usually eat a little of many plants of several species rather than consuming completely all available forage from a few plants. Although some species are preferred more than others, few are completely ignored. Also, species that are highly preferred in one season or area may be totally unattractive at other times or places.

In general, blacktails prefer green leafage which is most available to them during the growing season when most plants have leaves and succulent stems. Evergreen and semi-evergreen shrubs like salal and Pacific blackberry are characteristic of the region and provide leafage year-round in many locations. Conifers also offer year-round green feed when small trees are within reach of deer or when snow or wind break limbs from larger trees.

Browse, the feed produced by woody plants, provides the plant parts most eaten throughout the range (table 1) and increases in importance northward through the blacktail range. Deer eat the leaves of most deciduous species, but buds and twigs of most rank low as forage during dormant periods. Forbs are an important forage source (table 1), but are available primarily during growing seasons, which are progressively shorter as latitude and altitude increase. Forbs are about constant in importance over the region.

Grasses have long been recognized as important feed for blacktails (table 1). On more southerly ranges and at lower elevations, grasses begin growth after fall rains and provide green feed throughout the winter where snowfall is minimal. The only

Table 1. Annual diets of black-tailed deer on four Coast Range habitats (data adapted from listed sources).

Location and source	Browse	Forbs, fungi, other	Grasses and grasslike plants
	----------Percent----------		
California [Wildlife Investigations Laboratory, Undated]	49	27	24
Oregon [Crouch, Unpublished]	59	25	16
Washington [Brown, 1961]	65	25	10
Vancouver Island[1/] [Cowan, 1945]	71	27	2

1/ Percent of identified material.

other green feeds are residual leaves of evergreen trees and shrubs, and winter-active forbs. Grasses decline dramatically in importance to deer from south to north in the Coast Range.

Blacktails usually have abundant forage in some seasons, and face shortages in others. In most areas, more forage is available than can be utilized by reasonable numbers of deer in the late spring, summer, and fall. In winter, and early spring, feed may be severely restricted because of low residual supplies, inaccessibility due to snow cover, or poor early growth.

Table 2 shows seasonally important forage plants in four widely separated locations. Available evidence from all of these areas indicates that green feed is available and contributes most of the plant material eaten during most of the year. Even in winter, when succulent forage is traditionally scarce, blacktails still depend primarily on residual green leafage from the previous growing season, or on grasses and forbs that actually grow during winter. Nearly all of the plants listed in table 2 in winter provide green forage at that time.

Residual twigs of woody plants are generally of little importance to wintering deer in Coast Range habitats. Regionally, only huckleberry and several species of ceanothus are important shrubs providing substantial amounts of twigs. Although most winter feeding occurs in openings, mainly cutover or burned areas, several of the more common winter forage plants, including salal, grow abundantly in the forest understory. This is important, especially at more northerly latitudes, where blacktails characteristically depend on timbered sites for food and cover during winter [Jones, 1974].

Table 2. Major seasonal forage plants of black-tailed deer on four Coast Range habitats (data adapted from listed sources).

Location and source	Season: Spring	Season: Summer
California [Wildlife Investigations Laboratory, Undated]	Madrone Douglas-fir Whipplea Horsetail Grasses	Madrone Coast whitethorn Evergreen huckleberry Tobacco-brush Starflower
Oregon [Crouch, Unpublished]	Cats-ear Ocean-spray Bittercherry Blackcap Douglas-fir	Cats-ear Thimbleberry Bittercherry Vine maple Hazel
Washington [Brown, 1961]	Grasses Pacific blackberry Cats-ear Plantain Huckleberry	Pacific blackberry Cats-ear Plantain Vine maple Clover
Vancouver Island [Cowan, 1945]	Douglas-fir Willow Horsetail Bracken Salal	Salal Red alder Blackcap Willow Grasses

Location and source	Season: Fall	Season: Winter
California [Wildlife Investigations Laboratory, Undated]	Grasses Acorns Canyon live-oak Phacelia Salal	Grasses Tobacco-brush Horsetail Madrone Tanoak
Oregon [Crouch, Unpublished]	Pacific blackberry Blackcap Grasses Big deervetch Bittercherry	Grasses Pacific blackberry Iris Salal Blackcap
Washington [Brown, 1961]	Pacific blackberry Vine maple Red alder Huckleberry Plantain	Pacific blackberry Grasses Salal Huckleberry Plantain

Table 2. Major seasonal forage plants of black-tailed deer on four Coast Range habitats (data adapted from listed sources). (Continued)

Location and source	Season: Fall	Season: Winter
Vancouver Island [Cowan, 1945]	Salal Red alder Mushrooms Douglas-fir Willows	Douglas-fir Lichens Salal Mushrooms Redcedar

Blacktails seem to thrive on cutover and burned Coast Range habitats even where no timber cover is available, at least in the southern half of their range. These areas generally produce much larger quantities, and a far greater variety, of forage plants than stands of uncut timber.

Current estimates of deer numbers throughout the blacktail's range leave no doubt that both the food supply and the deer have capabilities for the production of large numbers of animals. Annual forage supplies should remain adequate as long as logging practices provide the combination of habitats and successional stages necessary for maintaining the black-tailed deer inhabiting any particular geographical region.

Table 3. Common and scientific names of plants in text and tables [mostly from Hitchcock and Cronquist, 1973].

Common names	Scientific names
BROWSE	
Acorns	*Quercus* and *Lithocarpus* spp.
Bittercherry	*Prunus emarginata*
Blackcap	*Rubus leucodermis*
Canyon live-oak	*Quercus chrysolepis*
Coast whitethorn	*Ceanothus incanus*
Douglas-fir	*Pseudotsuga menziesii*
Evergreen huckleberry	*Vaccinium ovatum*
Hazelnut	*Corylus cornuta*
Huckleberry	*Vaccinium parvifolium*
Madrone	*Arbutus menziesii*
Ocean-spray	*Holodiscus discolor*
Oregongrape	*Berberis nervosa*
Pacific blackberry	*Rubus ursinus*
Red alder	*Alnus rubra*
Redcedar	*Thuja plicata*

Table 3. Common and scientific names of plants in text and tables [mostly from Hitchcock and Cronquist, 1973]. (Continued)

Common names	Scientific names
BROWSE (cont.)	
Salal	*Gaultheria shallon*
Tanoak	*Lithocarpus densiflora*
Thimbleberry	*Rubus parviflorus*
Tobacco-brush	*Ceanothus velutinus*
Vine maple	*Acer circinatum*
Whipplea	*Whipplea modesta*
Willow	*Salix* spp.
GRASSES and GRASSLIKE PLANTS	*Cyperaceae*
	Graminae
	Juncaceae
OTHERS	
Lichens	*Usnea* sp.
Big deervetch	*Lotus crassifolius*
Bracken	*Pteridium aquilinum*
Cats-ear	*Hypochaeris* spp.
Clover	*Trifolium* spp.
Horsetail	*Equisetum* sp.
Iris	*Iris tenax*
Mushrooms	*Boletus* spp., etc.
Phacelia	*Phacelia bolanderi*
Plantain	*Plantago* spp.
Starflower	*Trientalis latifolia*

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Nutritional Interactions of Black-tailed Deer with Their Habitat in Southeast Alaska

by

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Introduction

Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) occur along the Pacific Coast from about 53° to 58° North latitude. Their range extends farther north and west than any other subspecies of *Odocoileus hemionus*. The northern extension of this range represents one extreme in environmental conditions that the species can tolerate. Sitka black-tailed deer could probably not exist in this area without some amelicrating habitat factors or physiological adaptations to the harsh environment. Habitat conditions and nutritional interactions of black-tailed deer with their habitat in southeast Alaska will be discussed in this paper.

Vegetation in southeast Alaska is notable for its lack of diversity. Two vegetation types, spruce-hemlock forests and alpine tundra, comprise nearly the entire range. Other minor vegetation types of some importance to deer are muskegs, slide patches and beach edges. Forage provided on beach edges consists mostly of *Carex* and halophytes. All vegetation types are used by black-tailed deer during summer, but alpine tundra is extensively used during snow-free periods and provides high quality range [Merriam, 1968]. During winter when snow prohibits use of alpine tundra, muskegs, and slide areas, spruce-hemlock forests comprise the primary range used by deer. Snow depth in low elevation climax forest is usually shallow enough to allow deer access to forage because dense stands of tall trees intercept a large portion of the snow. Deer move to beach edges during severe winters when snow accumulates to depths that preclude deer occupancy of the climax forest. Where climax forest exists, winter use of the tidal zone is minimized; where it is absent, deer concentrations are maximized. Seasonal habitat use by Sitka black-tailed deer is similar to that by Rocky Mountain mule deer and Columbian blacktails in many areas in that snow is the most important factor influencing distribution. Unlike mule deer, Sitka black-tailed deer move into forests as snow pushes them from alpine areas, whereas mule deer on some ranges move from the forest type to lower elevation shrub ranges.

Forage Resources

The late spring and summer forage supply for deer in southeast Alaska is abundant and of high nutritive value. The alpine tundra range has good species diversity and contains large quantities of species highly favored by black-tailed deer [Klein, 1965]. Species preferred by black-tailed deer on two islands in southeast Alaska contained from 13 to 36 percent crude protein and less than 30 percent crude fiber from May through August [Klein, 1965]. Analysis of washed rumen contents from deer on these islands revealed similar values [Klein, 1962]. Alpine tundra plants collected on the Canadian Cordillera in Alberta contained from 12 to 27 percent crude protein during early stages of growth [Johnston and others, 1968]. Although no digestibility trials have been conducted on plants collected from alpine ranges inhabited by Sitka black-tailed deer, trials on plants collected from alpine ranges in Wyoming also indicate high digestibility. Grasses averaged 64 percent, forbs and sedges 60 percent, and mat-forming plants 44 percent *in vitro* digestibility during the summer period of maximum standing crop [Smith, 1969].

The nutritive value of alpine plants declines rapidly after the seed-ripening stage [Johnston and others, 1968]. However, quality of deer diets probably remains high (13+ percent crude protein, 50+ percent digestibility) throughout the autumn. High quality diets probably continue through fall because deer are capable of selecting plants of high value in early stages of growth. Plant phenology varies greatly in different locations at a given time because of differences in slope, aspect, overstory cover, and snow persistence; deer in the autumn still have forage of high quality available. The average standing crop of vegetation on alpine tundra ranges in southeast Alaska has not been determined, but it probably exceeds the average of 1000 to 2000 kilograms per hectare for intermediate sites on alpine tundra ranges in Wyoming [Thilenius, 1975].

The quantity and quality of forage during winter is much diminished from summer. The spruce-hemlock climax forest is characterized by a lack of species diversity and low production in the understory. No nutritional studies of winter forage in this vegetation type have been published, but in Colorado I studied nutritive values of mule deer diets throughout an annual cycle. Crude protein content peaked at about 20 percent during June and decreased to less than 5 percent in February (fig. 1). *In vitro* digestibility declined to about 40 percent during mid-winter from a summer high of 60 percent. Similar trends in forage quality probably occur in southeast Alaska, although minimum values may differ.

Deer Nutritional Requirements

Black-tailed deer, like white-tailed and mule deer, exhibit annual cycles of metabolic rate, forage intake, body growth, and fat accumulation and depletion. Energy expenditure, inferred from measurements of fasting heat production (FHP), is highest during the summer when deer are in a productive state and lowest during mid-winter when they are in a maintenance state. Fasting metabolic rate of white-tailed deer averaged 143 kcal/kg$W^{0.75}$/day[1/] for summer and 96 kcal/kg$W^{0.75}$/day in winter [Silver and others, 1969]. Seasonal fluctuations in metabolic rate were further demonstrated by Thompson and others [1973] (fig. 2). Work by Nordan and others [1970]

1/ kcal/kg$W^{0.75}$ = kilocalories per kilogram of body weight raised to the 0.75 power.

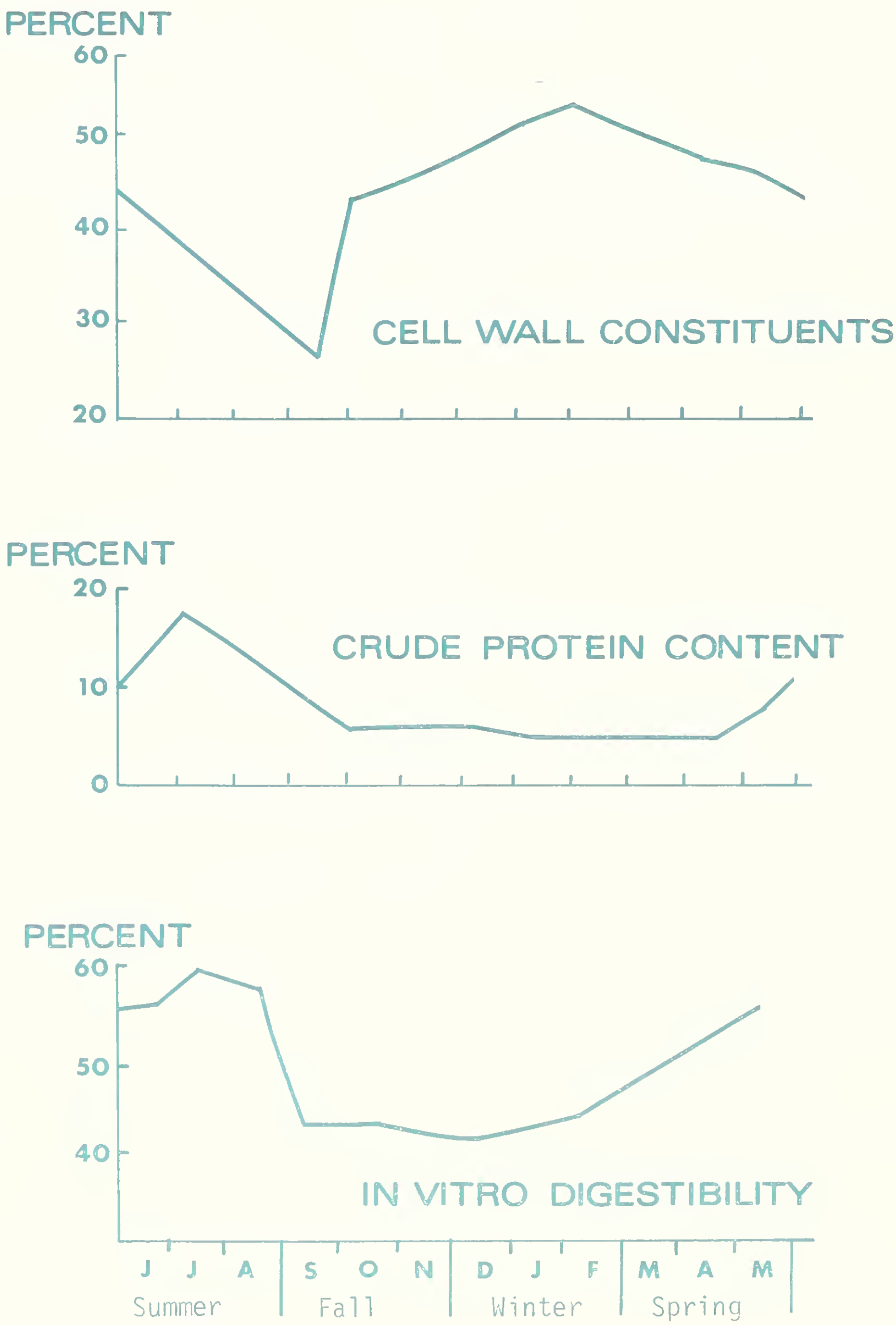

Figure 1--Annual cycle of cell wall constituents, crude protein content and *in vitro* dry matter digestibility of mule deer diets in Colorado

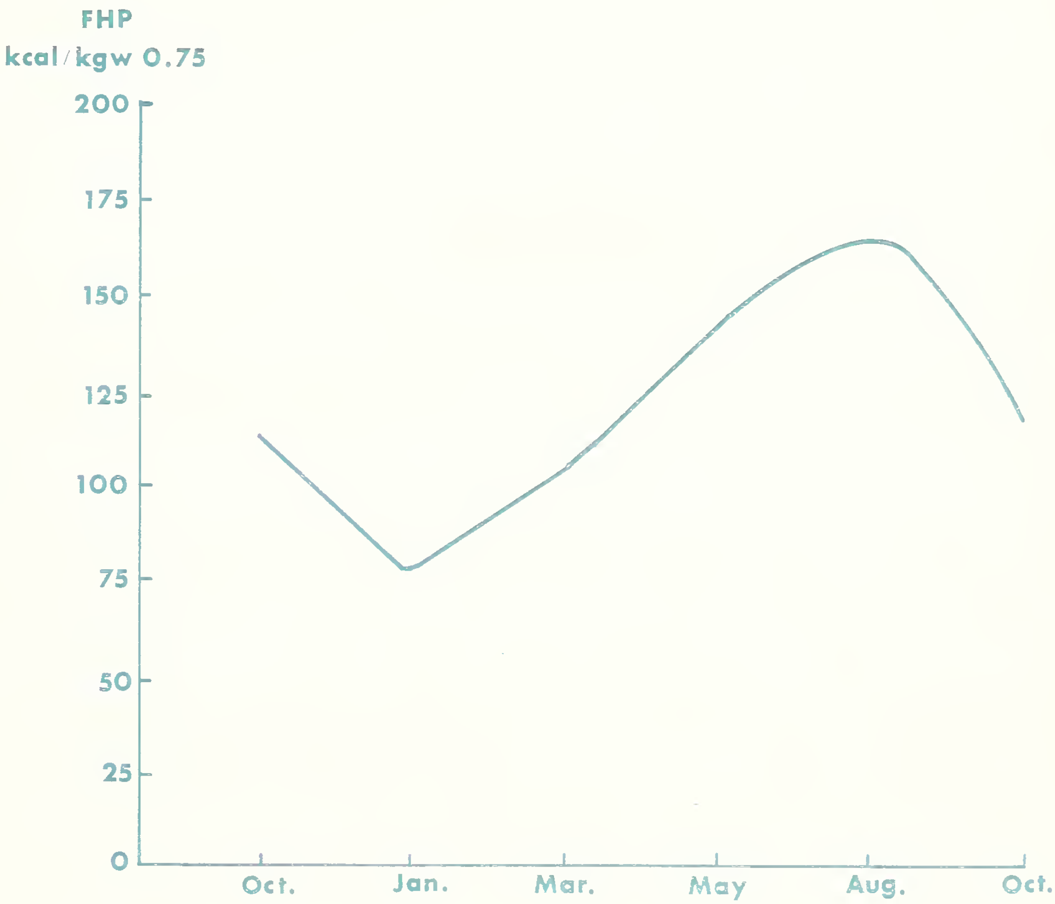

Figure 2--Annual cycle of fasting heat production in white-tailed deer. From Thompson and others [1973]

indicated that black-tailed deer have metabolic rates similar to white-tailed deer. Using Silver's values of fasting heat production (FHP), daily energy requirements (DER) can be approximated by multiplying the FHP by the animal's metabolic weight ($W^{0.75}$). For a 35-kilogram deer, the DER during summer would be 2057 kilocalories. Assuming the deer adds 10 kilograms of weight during the summer and fall, a 45 kilogram deer would require 1667 kilocalories per day during winter. The energy requirements of free-ranging deer may be higher than those calculated above because of the energy costs for activity. Moen [1973] estimated activity metabolic rates (AMR) to range from 1.23 to 1.98 times the interspecific mean basal metabolic rate of 70 kcal/kg$W^{0.75}$/day. The values of 143 and 96 kcal/kg$W^{0.75}$/day used in my calculations are within the AMR range estimated by Moen [1973].

Forage intake is also highest in summer. This was demonstrated with pen-fed Sitka blacktails by Bandy and others [1970] whose graphs indicated a late-summer high intake rate by bucks averaging about 25 grams/kilograms/day compared with a mid-winter low rate averaging about 17 grams/kilograms/day. For mule deer in the wild in Colorado, Alldredge and others [1970] estimated intake rates of adults to average about 21 and 17 grams/kilograms/day in summer and winter, respectively, while that of all age and sex classes combined averaged about 26 and 20 grams/kilograms/day in summer and winter.

Approximations of energy intake can be derived from such estimates. Gross energy content of most range forage plants is close to 4.5 kilocalories/gram; digestible energy (DE) is proportional to total dry matter digestibility [Robbins and others, 1975]; and, metabolizable energy (ME) is constantly about 85 percent of DE [Brody, 1945]. *In vitro* dry matter digestibility (IVDDM) is an adequate approximation of true digestibility for the present purposes. Estimates of ME intake can be calculated by: animal weight x intake x 4.5 x IVDDM x .85.

Assuming 70 percent digestibility for summer forage and an intake rate of 25 grams/kilograms/day, daily ME intake of a 35-kilogram (77-pound) deer would be 2343 kilocalories--268 kilocalories more than DER as calculated above. In winter, assuming average forage digestibility of 40 percent and intake of 17 grams/kilograms/day, the ME intake of a 45-kilogram (99-pound) deer would be 1170 kilocalories/day--497 kilocalories less than DER. The summer surplus of energy is used for growth and fat accumulation. Deer are capable of accumulating fat stores up to 15 percent of their total body weight [Anderson and others, 1972; Robbins and others, 1974a]. A 45-kilogram deer could easily enter winter with a reserve of 6 kilograms of fat. Body fat yields about 6.5 kilocalories/gram when catabolized [Wallmo and others, 1977]. A 6-kilogram fat reserve will allow deer to survive an energy deficit of 500 calories a day for about 80 days.

Deer in Alaska likely undergo periods of energy surplus and deficit similar to those presented in the hypothetical example. Obviously, the processes are much more complex than I have outlined. Changes from an energy surplus to a deficit do not normally occur rapidly, but follow the gradual decline associated with forage quality. However, winter survival of deer in southeast Alaska depends to a great extent on their ability to accumulate fat during the summer and on the length and severity of the following winter. Winters which last late into the normal spring period could cause extensive population losses due to starvation.

The phenomenon of voluntary reduction of forage intake by deer during winter when they are in a state of negative energy balance has been observed by numerous researchers. Such reductions of intake occurred in both sexes of black-tailed deer [Nordan and others, 1970; Wood and others, 1962]. Males drastically reduce their intake with the onset of rut and maintain a reduced level throughout the winter, whereas females decrease their intake more gradually throughout the winter. As forage quality decreases the levels of intake and metabolic rate decline. Deer are forced to

restrict their intake of forage as its quality declines due to a slower rate of passage of high fiber material through the digestive tract and associated rumen fill [Campling and others, 1961; Ammann and others, 1973]. The rate of passage of ingesta out of the rumen is controlled by the rate of digestion [Campling, 1970] which is strongly influenced by the amount of nitrogen in the rumen [Hume and others, 1970]. The nitrogen level in the rumen depends on the crude protein content of ingested forage and the deer's ability to recycle nitrogen. The fact that black-tailed deer restrict their intake even when they have unlimited access to high quality feed [Nordan and others, 1970] indicates that deer have adapted, through evolution, to periods of low forage quality.

Crude protein content of forage is widely used as an indicator of forage quality. However, the protein or nitrogen requirements of deer are poorly understood because they are confounded with nitrogen recycling, catabolism of muscle tissue, energy intake and other factors. A diet containing 16-17 percent crude protein meets maximum requirements for growing fawns and lactating does [French and others, 1956; Ullrey and others 1967; Verme and Ullrey, 1972]. Smith and others [1975], who conducted experiments which quantified the maximum nitrogen requirements of white-tailed deer fawns, held energy intake constant, and varied the protein content of a ration fed to weaned fawns. The requirement for maximum growth was 3.05 grams digestible nitrogen per $kgW^{0.75}$ per day, roughly the equivalent of 25 percent crude protein at their level of intake. However, the most efficient use of nitrogen occurred on feed with 11 percent crude protein.

A crude protein level of 7 percent is often quoted as the minimum necessary for maintenance. This figure originated from work conducted by French and others [1956] and Murphy and Coates [1966]. However, deer do survive when crude protein levels of forage are less than 7 percent. The 7 percent level is probably required to maintain positive nitrogen balance [Robbins and others, 1974b]. When the crude protein content of forage is below this level, deer catabolize muscle tissue. The degree to which deer can use muscle tissue as a nitrogen source without damage is not known. Deer forage in southeast Alaska appears to exceed summer requirements for crude protein, but winter levels may be below minimum requirements.

Effects of Logging on Deer Habitat

To evaluate the effects of logging the climax spruce-hemlock forests on black-tailed deer habitat, it is necessary to understand snow depth patterns and forest succession following logging. At lower latitudes in drier forest types, logging can improve deer habitat [Resler, 1972; Pengelly, 1972]. Understory production, species diversity, and overall forage quality have been substantially increased when the overstory was removed [Brown, 1961; Lawrence, 1969; Wallmo and others, 1972; Regelin and others, 1974]. However, these studies were conducted in areas where the forest habitat was used primarily by deer during the summer. Snow depth in clearcut areas is much greater than in adjacent uncut areas due to interception of snow by trees. Merriam [1971] found snow was about twice as deep in openings as in mature timber in southeast Alaska. On northern Vancouver Island, Jones [1974] reported snow depths of 15 centimeters in the forest whereas clearings contained up to 75 centimeters of snow. On central Vancouver Island snow depth at about 700 meters elevation in a 23-year-old regrowth forest was about twice that in adjacent stands over 250 years old [Weger, 1977]. Mule deer in Colorado did not occupy areas where snow depth exceeded about 50 centimeters [Gilbert and others, 1970]. This limit may be somewhat less for black-tailed deer because of their smaller size, and much less in southeast Alaska because of the extreme density of the snow.

The successional pattern following clearcut logging in southeast Alaska was examined by Robuck [1975]. He reported that 20 years after logging the overstory had shaded out understory species. For the next 180 years the forest floor supported very little herbaceous vegetation or vascular shrubs. About 200 years after logging, the understory again developed as the overstory opened and allowed more sunlight to reach the forest floor. These observations indicate that logging would increase deer forage supplies for about 20 years, if snow depth is not considered. Subsequently, logged areas are of negligible value to deer for nearly 200 years. Merriam [1971] reported similar findings during early successional stages but believed that forage was available in the forest about 60 years after logging. A study on Vancouver Island [Weger, 1977] also indicated that habitat quality was diminished for at least 75 years. More research must be conducted on forest succession following logging in southeast Alaska before definite conclusions can be drawn on the effect of logging on deer.

The preceding information suggests that logging in southeast Alaska may have an overall detrimental effect on black-tailed deer. In fact, the one ameliorating factor which allows deer to survive in Alaska may be the existence of the climax spruce-hemlock forest. These over-mature, mixed-age forests have a greater biomass of evergreen forbs and palatable shrubs than even-aged, submature forests. The floor in the climax forest remains free of snow, or has shallow snow depths for most of the year, thus minimizing the energy-deficit period for deer. Managers must consider multiple-use forest management practices that allow for the importance of the climax forest to Sitka black-tailed deer and preserve adequate amounts of this forest type. Deer would not be eliminated by logging in southeast Alaska. Many areas are impractical to log, and forest management policy currently provides for the preservation of some old-growth forest specifically for deer. But it appears that every acre of old-growth forest that is removed by any cause (wind, fire or logging) represents a decrease in the potential of that area to support deer.

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Timber Management and Deer in Southeast Alaska: Current Problems and Research Direction

by

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Introduction

The geographic distribution of *Odocoileus hemionus* roughly covers the western third of North America. The 3 largest races, the Rocky Mountain mule deer, Columbian black-tailed deer, and desert mule deer, have large geographic ranges which include great habitat diversity (fig. 1). The remaining 6 races have relatively small geographic ranges, especially at the extreme southwest and northwest limits of their distribution.

The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) occupies a very narrow range, between the ice-capped Coast Range and the sea, at the northwest extent of the species' natural distribution. Its habitat is dominated by 2 major vegetation types--temperate rain forest and alpine tundra. Heavy snow accumulation during winter is characteristic of this region. The alpine zone is highly productive of deer forage but is snow free for only 3 to 5 months of the year. For 7 to 9 months, deer are confined to the lower forest zone. In most winters, deep snow extends well down into the forest zone, often to sea level. Least snow depths occur in old, high-canopied forests, while in openings snow accumulation is much greater [Jones, 1975; Merriam, 1968, 1971; Weger, 1977]. Of the forest habitat that is usable in winter, uneven-aged old-growth stands provide the most available forage for deer (discussed later).

The Alaska Department of Fish and Game and the U.S. Forest Service have mandates to maintain and enhance the populations and habitats of deer in southeast Alaska. Timber harvesting is the man-related factor influencing the largest amount of deer habitat in this region. The Forest Service has estimated that the volume of wood fiber produced per acre from second-growth forest stands will increase approximately 70 percent over the volume produced from old-growth stands [USDA Forest Service, 1977]. Thus, harvesting of old-growth stands will provide more land for regeneration and will increase long-term yields. The planned rotational cycle for timber harvest in southeast Alaska is approximately 100 years [USDA Forest Service, 1969]. Clear-cutting appears to be the most economical method of harvesting this resource.

In 1977, the Alaska Department of Fish and Game and the Forestry Sciences Laboratory of the Pacific Northwest Forest and Range Experiment Station initiated a cooperative research program with the general objective of obtaining information on deer management-timber management relationships. This paper reviews some of our preliminary findings and their implications.

Research Direction

The research program we have formulated begins with studies of use of natural habitat by deer uninfluenced by other land use activities, and builds from there to studies of specific land-use practices to determine their potential for improving or impairing deer habitat. These proposed studies include:

1. Seasonal and daily use of natural habitats.

    a. Distribution patterns.
    b. Movements and activity patterns.
    c. Elevations, slopes, aspects, vegetation types, plant species and snow conditions associated with distribution.

2. Food habits and annual nutritional regimes.

    a. Forage species used.
    b. Nutritional quality of forage species.
    c. Nutritional status of deer.

3. Forage production in old-growth forests and even-aged regrowth during the post-logging sere.

    a. Changes in understory composition and biomass during the post-logging sere (Forest Service contract with Oregon State University).
    b. Composition and density of understory vegetation as related to density of even-aged regrowth forest (conducted under a silviculture research program directed by W. Farr).

4. Relative use by deer of old growth and even-aged regrowth of various ages.

5. Relative snow depths in, and winter deer use of, old growth and even-aged regrowth of various ages and stand densities.

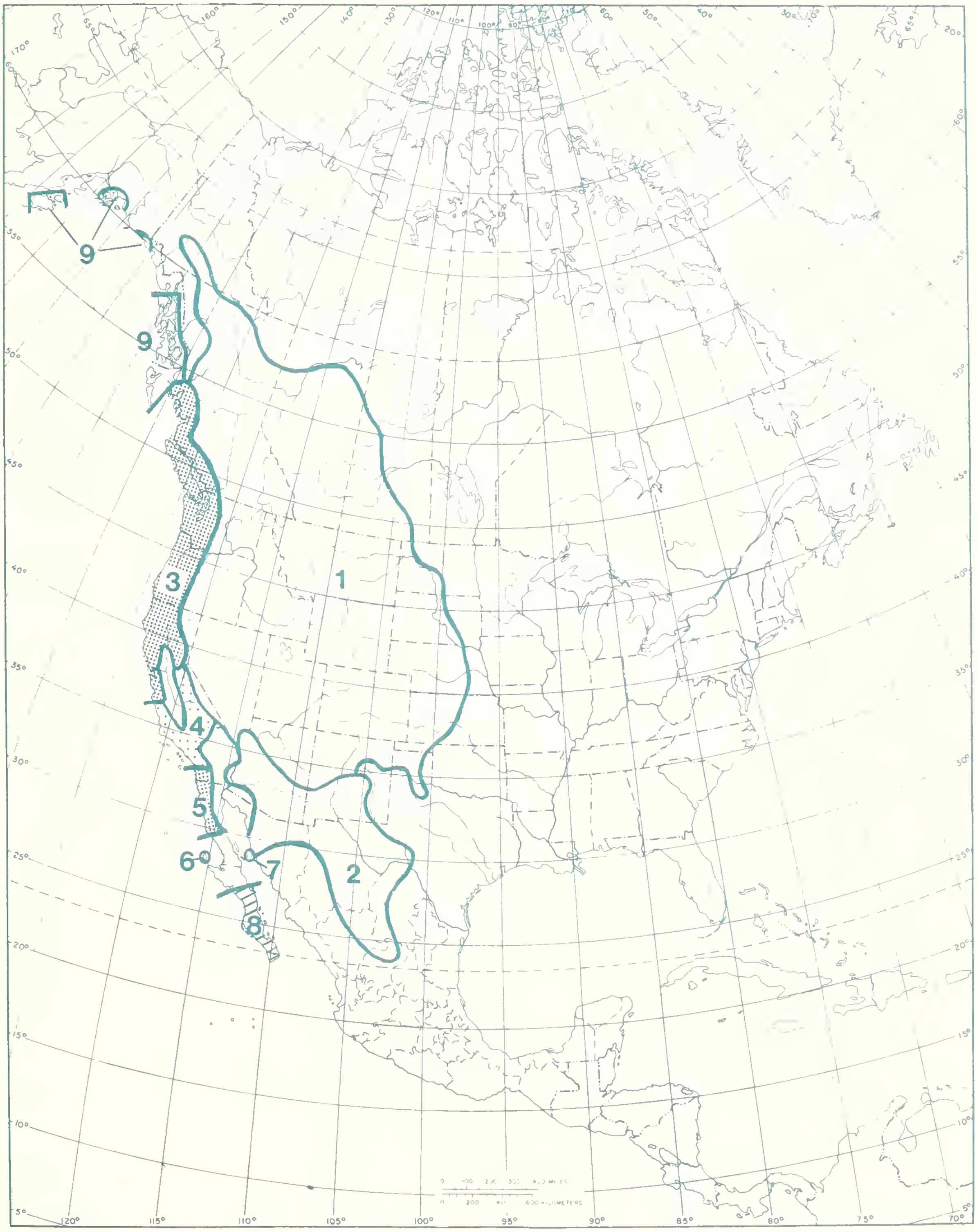

Figure 1. Geographic distribution of the races of Odocoileus hemionus. Races are 1-hemionus, 2 crooki, 3 columbionus, 4 californicus, 5 fuliginatus, 6 sheldoni, 7 cerrosensis, 8 peninsulae, and 9 sitkensis.

Because present forest use and management practices indicated an urgent need for an understanding of logging-related and silviculture-related influences on deer, we have placed initial emphasis on items 3 and 4.

Preliminary Results

Relative use by deer of old-growth and regrowth forests--It may be assumed that, where the choice is available, the amount of use deer make of one habitat relative to another will suggest the relative quality or value to deer of the two habitats. This study was conducted to determine if differential use occurs; later studies will be concerned with identifying and quantifying the causes.

We selected study areas on Admiralty and Chichagof Islands (fig. 2) which had sufficiently high deer densities to provide adequate measurements of relative use and which offered a range of stand ages. At each area, a stand of even-aged regrowth forest, or recent clearcut, was compared with an adjacent or nearby uneven-aged over-mature, or old-growth, forest on a similar site. Relative pellet-group densities were used as the indicator of relative deer use. Our study plan called for sampling in fall and spring for estimates of summer and winter use, respectively. [See Fisch, 1978 and Bunnell, 1978 in these proceedings.] This paper reports on results of the first fall sample, September-October 1977.

The sample in each stand consisted of parallel lines of contiguous 1- x 10-meter plots with the lines arbitrarily spaced to cover the stand. In the fall operation, sample size varied from 113 to 310 plots per stand because of inexperience with logistical problems. (Future samples will consist of 300 plots in each stand.)

Abbreviated results of the fall 1977 sampling are presented in table 1 and fig. 3. They indicate that the regrowth stands as a whole received an average of 1/5 as much use as did the old growth as a whole.

On the basis of this first sample, we can construct a tentative model of summer use of regrowth stands during the post-logging sere (fig. 4). Note than an increase in use over that of the old-growth forest was not measured in our youngest stands (4, 6-10, and 7-11 years). Instead, use was about 1/3, 1/2, and 1/7 that of the nearby old growth. Our observations suggest that within about 15 years, shrubs and trees, plus residual slash, generally become too dense for normal use by deer. It is not until 30 or 40 years that these stands begin to open up and allow unobstructed movement through them.

If there is an increase in deer use in the early years after clearcutting, we have not yet measured it. In Colorado, Wallmo and others [1972] reported a decrease in deer use for 2 years after logging, but an increase 10 years later. Here, in southeast Alaska, we measured a significant decrease in deer use as early as 4 years after logging and continuing to 147 years. Thus, the assumed early seral benefits to deer, if they exist, need to be identified, bracketed in time, and quantified. On southern Vancouver Island, Weger [1977] measured deer use in mature (250+ years) and immature (13-75 years) stands. He found that the mature stands received significantly higher use than the immature stands. On northern Vancouver Island, Jones [1974] observed that deer use of mature timber habitats was generally higher than use of logged habitats.

Forage production in old-growth and regrowth forest stands--Vegetation measurements, a secondary aspect of our fall field work, were discontinued because they were too costly of time and would have prohibited completion of our pellet-group sampling

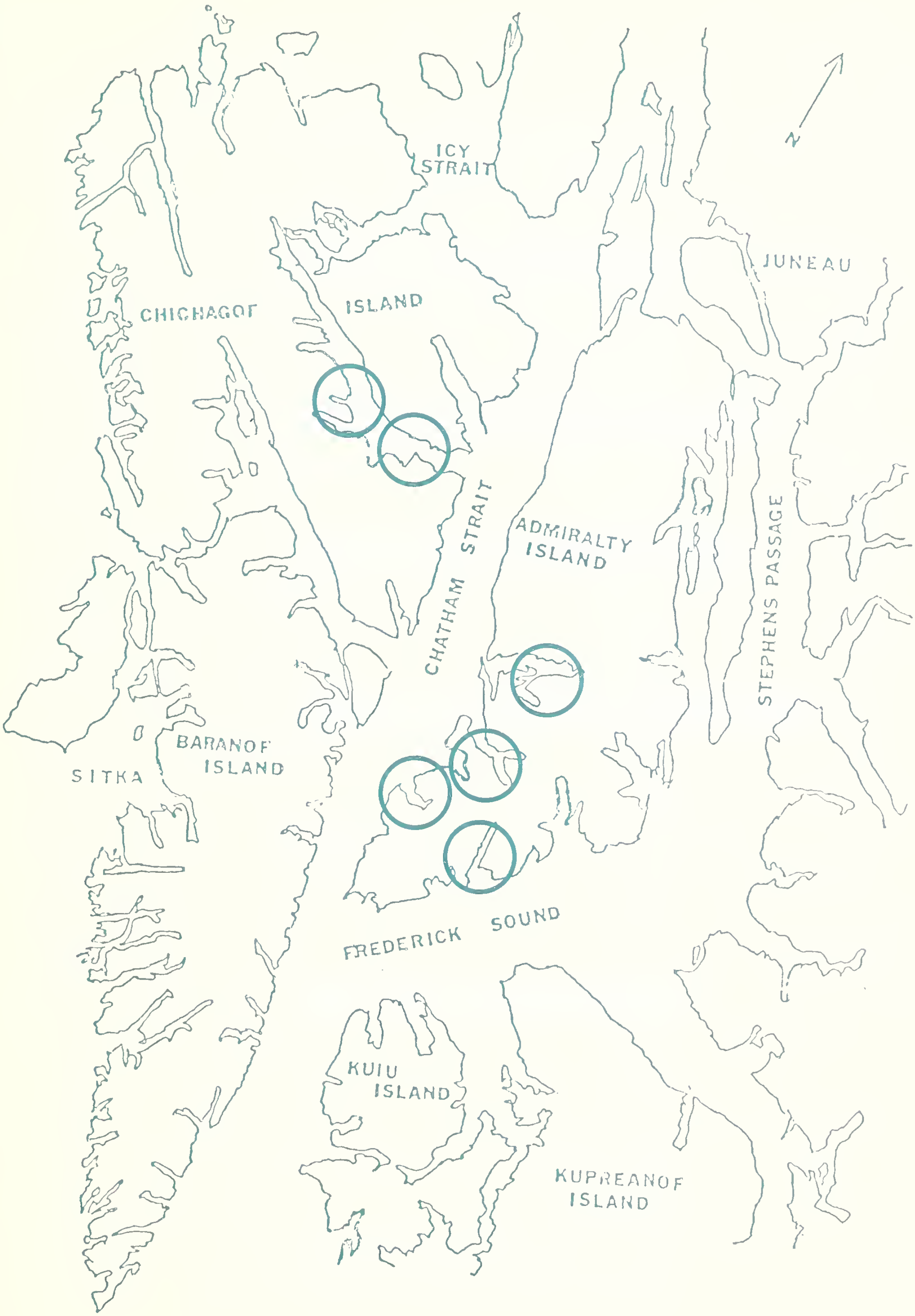

Figure 2. Location of deer use study sites, Fall 1977.

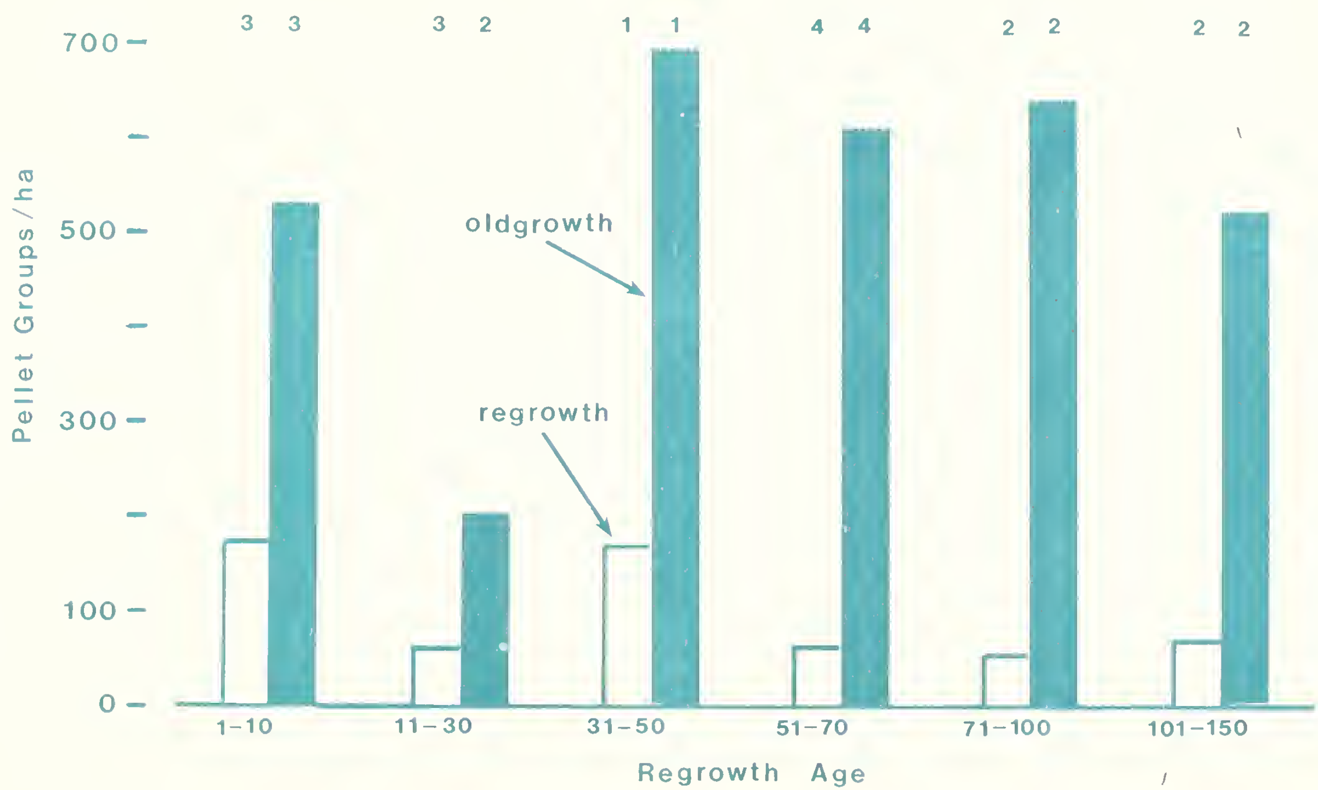

Figure 3. Comparative deer use of old-growth and regrowth stands on Admiralty and east Chichagof Islands, Fall 1977. Number of sample areas in each age category indicated at top.

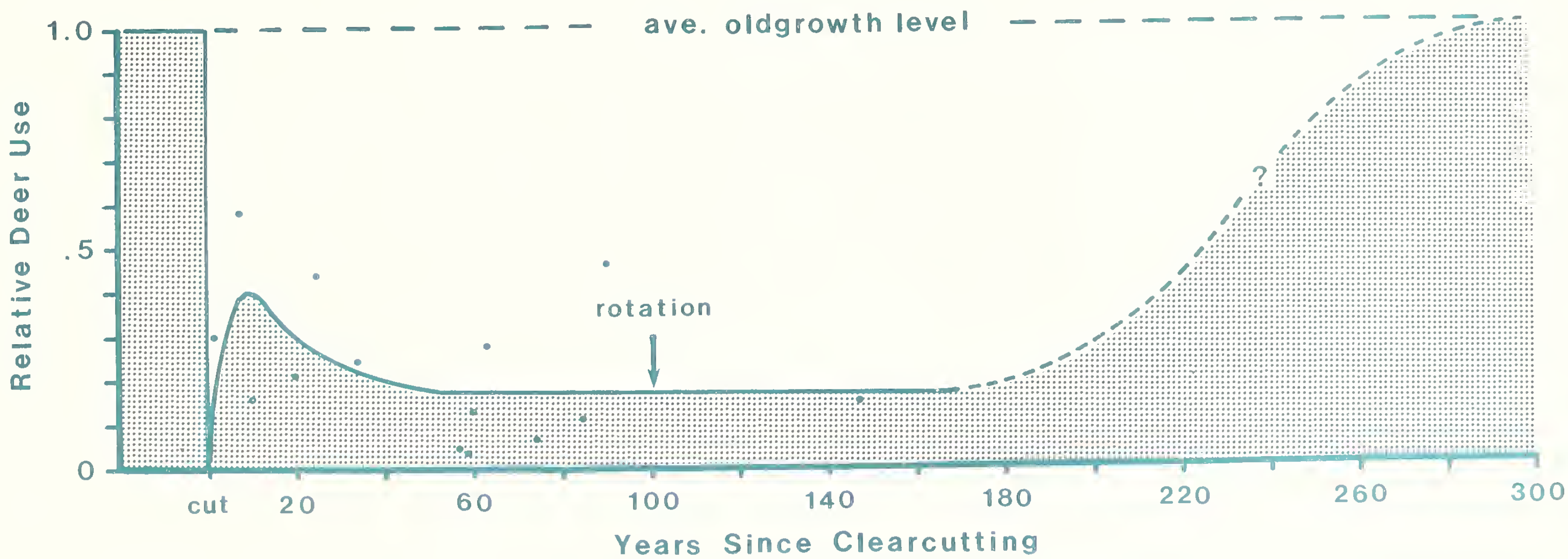

Figure 4. Relative effect of forest succession on summer deer use levels following clearcutting; points represent actual measurements of deer use relative to average use of old growth.

Table 1. Relative pellet-group density in old-growth and regrowth stands on Admiralty and Chicagof Islands, Fall 1977

Age of regrowth (years)	Number of plots[1/] Regrowth	Old growth	Ratio Old growth:Regrowth	Significance[2/]
4	309	310	3:1	**
6-10	240	245[3/]	2:1	N.S.
7-11	275	290	7:1	**
20	200	163	5:1	**
25	233	113	2:1	**
30-34	238	240	4:1	**
57	265	269	22:1	**
59	300	300	29:1	**
60	240	245[3/]	8:1	**
63	238	300	4:1	**
72	300	304	16:1	**
85	195	194	9:1	**
112	200	200	2:1	*
147	200	200	7:1	**
	Σ 3433	$\bar{X}$ 3128	5:1	**

1/ Plot size = 1 x 10 meters
2/ ** = $P<.01$, * = $P<.05$, N.S. = $P>.05$
3/ Same old growth comparison

(our first priority). The data collected (table 2) indicate that even-aged regrowth stands from 30 to 63 years old have less understory vegetation, consisting mainly of herbaceous species that die back in the fall and, when present, small *Vaccinium* plants. Uneven-aged old-growth forests have a substantially greater understory, larger and more robust *Vaccinium*, and abundant evergreen herbaceous species (for example, *Cornus*, *Tiarella*, *Coptis*, and *Rubus pedatus*).

Oregon State University, under contract with the Pacific Northwest Forest and Range Experiment Station, is currently investigating the productivity of the understory community in old-growth and regrowth forest stands throughout the Tongass National Forest. Preliminary data indicate an early increase in the biomass of herbaceous vegetation and shrubs after logging following by a rapid decrease to levels below those in the old-growth forest. Since these data are still being collected and analyzed, we are unable to report further at this time.

Harris [1974] reported the impoverished nature of the understory under even-aged regrowth stands throughout southeast Alaska. Robuck [1975] has estimated that once the understory is shaded out, the forest floor remains relatively free of shrubs, herbs, and ferns until about stand age 200 years. This is about twice as long as the current rotation cycle for this region.

Table 2. Summary of vegetation sampling in old-growth and regrowth forest stands on Admiralty Island, Fall 1977

Stand age (years)	Number of Plots1/	Plants/plot	Plots with vegetation %	Mean plants/plot Shrubs	Forbs	Ferns
30-34	238	7.67	71	0.87	3.51	2.63
Old growth	238	26.16	96	1.13	12.00	11.84
57	267	1.48	25	0.29	0.52	0.60
Old growth	140	38.14	86	3.13	32.34	1.65
59	300	1.46	19	0.33	0.34	0.79
Old growth	97	22.37	93	2.53	17.87	1.84
63	238	4.53	61	2.15	0.97	0.81
Old growth	300	12.58	74	3.54	6.66	1.67
Regrowth	1043	3.58	42	0.86	1.25	1.17
Old growth	775	22.59	84	2.60	4.78	4.78

1/ Plots = 0.5 square meters

Snow depth and winter deer use in old-growth and regrowth forests--In December 1977, snow measurements were made in a highgraded (selectively cut) uneven-aged forest and in an adjacent 8-year-old clearcut near Juneau. Both sites had southwesterly aspects and 10-20-percent slopes. One hundred snow measurement points in each site yielded a range of 48-110 centimeters (mean = 63 centimeters) depth in the clearcut with all points snow covered and a range of 0-58 centimeters (mean = 14 centimeters) in the forest with 29 percent of the points having no snow or only a trace of snow. Numerous deer tracks were observed in the forest and none in the clearcut.

On February 2, 1978, this same clearcut had a mean snow depth of 26 centimeters with 17 percent of the points (number = 100) bare. The forest had a mean snow depth of 0.9 centimeters with 82 percent of the sample points bare. Eighty-four percent of the forest plots (number = 25) had understory plants with green leaves; 72 percent had *Vaccinium* plants. Current deer sign was encountered in the forest but not in the clearcut. The continuation of this study in the same area and 2 other areas was aborted because of an extensive rainy period.

Jones [1975], Merriam [1971], and Weger [1977] reported that from 2 to 3 times more snow accumulates in openings than under old-growth forests. On south-central Vancouver Island, Weger [1977] measured average snow depths of 33 and 54 centimeters (at 640- and 740-meter elevation) in 23-year-old regrowth compared with 12 and 34 centimeters in adjacent mature (250-year) timber. Moreover, depths were much more variable in the timber than in the clearcuts.

We have inadequate knowledge of the effect of age, canopy height, and density of regrowth stands on snow accumulations. The information available, however, suggests that to better reflect deer winter use of the post-logging sere, the model of summer use (fig. 4) can be modified to something of the approximate nature of fig. 5. Thus the usefulness to deer of productive early successional clearcuts appears to be nil, or of limited value, during the critical winter periods of high snow accumulation.

Food habits and nutrition--We have made little progress on the food habits study. An evaluation of microscopic fecal analysis by Katherine Hazard, Forestry Sciences Laboratory, suggests that it is not a highly reliable technique. This is supported by results of a concurrent evaluation by the Colorado Division of Wildlife. Whatever methods are used, adequate food habits research will require a major investment of time and funds; so it must be deferred for now.

From Hazard's work, earlier Alaska Department of Fish and Game studies, and other sources, however, we have some knowledge of winter forage species used by deer. Samples of 11 species were collected in January 1978 and analyzed for several nutritional parameters by the University of Alaska Agricultural Experiment Station (table 3).

Crude protein content of three deciduous shrubs, *Menziesia ferruginea*, *Vaccinium* spp., and *Rubus spectabilis*, was 8.7, 9.1, and 11.2 percent, respectively. They all had well-developed leaf buds and, no doubt, higher protein levels than could be expected in early winter.

Crude protein content of the green-leaved forbs and subshrubs ranged from 10.1 to 19.6 percent, in the order *Coptis*, *Cornus*, *Rubus pedatus*, *Tiarella*, *Pyrola*, from lowest to highest.

Cell-wall content (inversely, an indicator of digestibility) of the three deciduous shrubs was *Rubus spectabilis* 64.0 percent, *Vaccinium* 62.1 percent, and *Menziesia* 61.5 percent. Cell-wall content of the green-leaved forbs and subshrubs ranged from

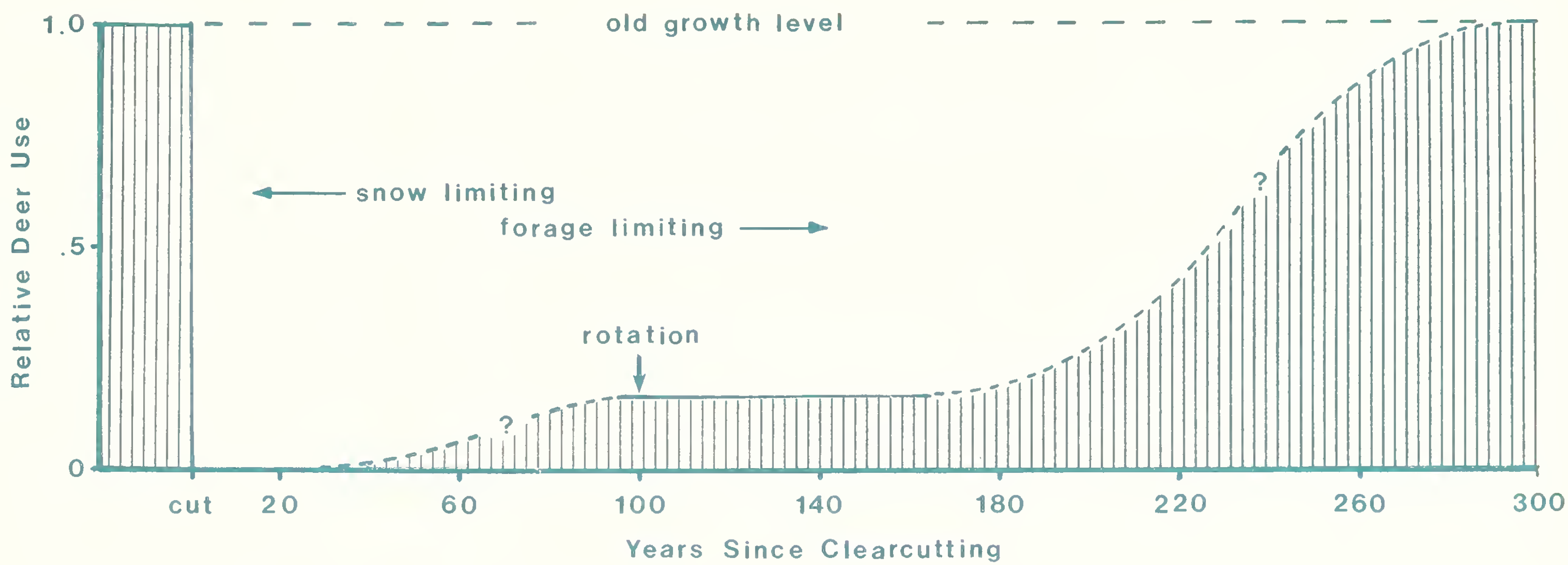

Figure 5. Hypthetical effect of forest succession on winter deer use levels following clearcutting.

Table 3 Composition of 11 winter forage species in terms of certain nutrition-related parameters

	Crude Protein	Cell-wall (NDF)	Acid-detergent fiber (ADF)	Lignin (ADL)	Residual ash
	----------	----------	percent	----------	----------
Pyrola secunda	19.6	21.7	18.7	16.0	2.8
Tiarella trifoliata	12.5	23.7	21.3	12.2	1.5
Rubus pedatus	12.1	32.7	21.7	17.5	1.8
Cornus canadensis	10.4	33.2	26.4	29.5	1.6
Coptis asplenifolia	10.1	38.9	30.7	15.3	1.6
Rubus spectabilis	11.2	64.0	47.2	39.6	1.6
Tsuga heterophylla	9.4	45.2	39.7	37.3	1.3
Vaccinium spp.	9.1	62.1	49.0	35.5	2.9
Menziesia ferruginea	8.7	61.5	46.1	41.2	2.6
Usnea sp.	3.5	16.0	4.2	31.0	1.0
Liverwort	11.8	50.8	27.4	10.9	7.5

21.7 to 38.9 percent, in the order *Pyrola*, *Tiarella*, *Rubus*, *Cornus*, *Coptis*, exactly inverse to protein content. That is, plants with the largest amount of highly digestible cell content have the lowest amount of poorly digestible fiber, or cell-wall material.

Furthermore, lignin, the most indigestible fraction of fiber, was highest in the deciduous shrubs (*Menziesia* 19.0, *Rubus spectabilis* 18.6, and *Vaccinium* 17.4 percent), and relatively low in the green-leaved plants (*Cornus* 7.8, *Coptis* 4.7, *Rubus* 3.8, *Pyrola* 3.0, and *Tiarella* 2.6 percent). Of all plants sampled, the arboreal lichen, *Usnea*, had the lowest lignin content (1.3 percent).

We were unable to obtain estimates of digestibility in time for this report, but a rough estimate can be obtained from the relationship of lignin content to fiber content as obtained by the acid-detergent method. A general predictive equation was calculated from the relationship of the average digestibility of general classes of forage to the product ADF x ADL for these classes (fig. 6).

This procedure suggests that the digestibility of the deciduous shrubs is low, of hemlock somewhat higher, and of the green-leaved plants very high. *Usnea* has the highest hypothesized digestibility but extremely low protein content. [See Bunnell in this volume for further information on this subject.]

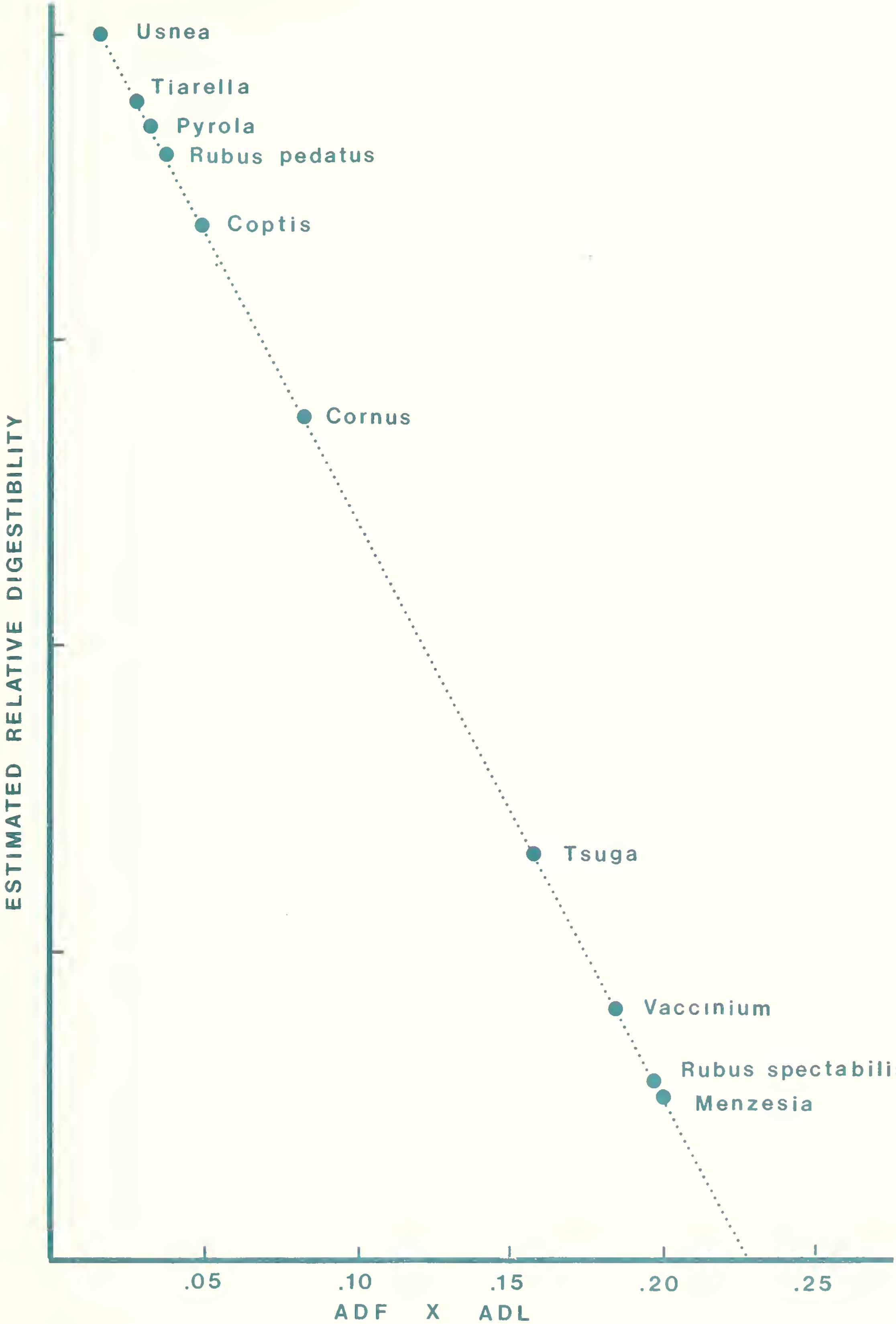

Figure 6. Hypothesized digestibility of several winter forage species based on cell-wall contents. ADF=acid detergent fiber. ADL=acid detergent lignin.

These results indicate the importance of green forage to wintering deer. Our sampling of understory vegetation indicates that such forage is most abundant in the old-growth forest. Our snow measurements indicate that it is also most available during winter in old growth. Even in winters where snow depths become excessive for deer everywhere, it takes longer to reach such depths in old growth and, therefore, the period of starvation conditions is less prolonged.

Seasonal and daily use of natural habitats--We propose to approach this phase of the investigation through radio-telemetry. By monitoring individual animals through daily and seasonal periods, we will be able to elucidate their home range characteristics and activity patterns as well as determine seasonal preferences for specific landscape attributed (for example, elevations, slopes, aspects and vegetation types).

Implications of Preliminary Results

Preliminary data collected thus far indicate the following:

1. For the areas we have measured, deer use of regrowth stands (ranging from 4 to 147 years) averaged about 1/6 that of the nearby or adjacent old-growth forest.

2. We have yet to observe an area or age class (including early successional clearcuts) where deer use actually increased following logging.

3. Regrowth stands from 30 to 63 years old produce substantially less understory vegetation (deer forage) than does the adjacent old-growth forest.

4. The only snow depth comparisons we have made revealed that, even during a moderate winter, a recent clearcut was relatively unusable for deer, while the adjacent uneven-aged, highgraded forest was usable.

5. Green-leaved forbs and subshrubs are more nutritious than deciduous browse during winter. In study areas near Juneau, green-leaved forbs and subshrubs were more generally abundant and avilable during winter in uneven-aged old growth than in an 8-year-old clearcut.

We reemphasize that these are preliminary and partial results of incomplete studies. We cannot ancitipate whether or how much they will be qualified by future data--nor can the forest manager. So today we find ourselves unable to accept the contention that logging is generally beneficial to deer or to reject the possibility that it is generally harmful in southeast Alaska.

While we are pursuing the research as rapidly as time, staffing, funding, and other obligations permit, we feel obliged to expose interim data to the scrutiny and criticism of those responsible for resource management. Existing policy of the Tongass National Forest states [USDA Forest Service, 1977, page 90] that timber harvesting will be planned to protect or enhance wildlife habitat. If the hypotheses presented here prove true, what adjustments would be necessary to protect or enhance existing deer habitat?

There are reported to be about 11.2 million acres (4.5 million hectares) of forested area in southeast Alaska and about 4.9 million acres (2 million hectares) of commercial forest land [Hutchison and LaBau, 1975]. Approximately 87 percent of this commercial forest land is estimated to be in old-growth forest [USDA Forest Service, 1977].

The first Alaskan sawmill was built in the early 1830s; and in the 1850s, Russian mills near Sitka were producing 3,000 board feet of lumber daily. Between 1910 and 1920, 420 million board feet of sawtimber and pilings were sold; in 1920, 100 million board feet from Admiralty Island were consigned to Alaska Pulp and Paper Company; in 1923, six mills were cutting lumber in large quantities. In World War II, about 85 million board feet were cut; since 1953, over 250,000 acres have been clearcut and about 18,000 acres are being harvested annually on the Tongass [Harris and Farr, 1975].

As yet we do not have a complete record of the total amount of land that has been logged--or how, when, or where. Nor do we know where the classified commercial acreage occurs with relation to seasonal habitat utilization by deer. Assuming that the commercial forest land occurs largely at lower elevations and on gentle to moderate slopes (about 50 percent occurs on slopes of less than 35 percent [Hutchison and LaBau, 1975]), we might expect a large amount of the most readily harvestable timber to substantially overlap deer winter range.

Clearcutting and even-aged regeneration appear to be the most efficient method of harvesting and producing timber in southeast Alaska, and the current program of sustained yield management calls for a rotation period based on a 100-year cycle. Our observations indicate that this management policy would impair deer habitat on "managed" sites forever.

Assume that over 1/2 million acres (.2 million hectares) or 13 percent of the commercial forest land in the Tongass are already under even-aged management, that 18 thousand acres (7.3 thousand hectares) are put under management annually, and that second-growth stands will be reharvested at about age 100 years. Further assume that windthrow, slides, and other natural processes increase this conversion of old growth to second growth to 20 thousand acres (8.1 thousand hectares) annually. A hypothetical model of this situation (fig. 7) traces the decline of optimum winter deer habitat from over 4 million acres (1.6 million hectares) today to almost none in 200 years.

Too many variables are involved to use the above example as a prediction of the future. Nevertheless, it is presented to convey the urgency of the need for timber managers to clarify for deer managers the projected rate of liquidation of old-growth forest in southeastern Alaska. Conversion of the uneven-aged climax forest naturally occurring throughout southeastern Alaska to even-aged regrowth ("managed") stands will substantially alter deer habitat from that naturally occurring within the Tongass Forest. Whether or not this change is in the direction indicated by our studies, those responsible for managing deer habitat for the maintenance of reasonable population levels must be in a position to anticipate the potential and long-term effects timber management may have on this resource.

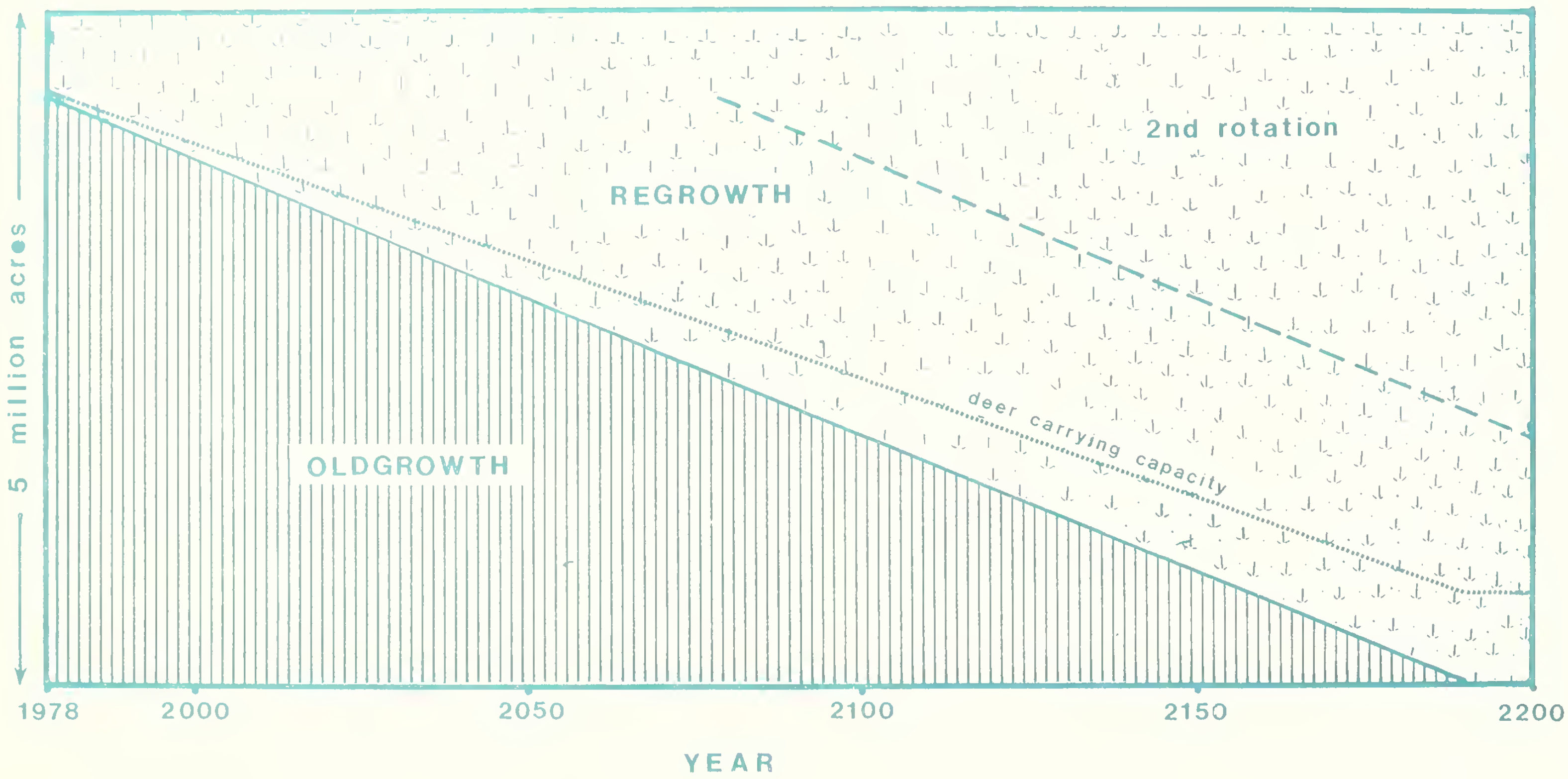

Figure 7. Hypothetical model demonstrating the reduction of the climax forest over time and its impact on optimum winter deer habitat.

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Deer-Forest Relationships on Northern Vancouver Island

by

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Relationships between black-tailed deer (*Odocoileus hemionus columbianus*) and forests on northern Vancouver Island have been studied for almost a decade. This paper provides an overview of these studies and notes some of the major findings. All research efforts are bounded by both the broad, conceptual framework within which they are embedded and their historical development. It is important to acknowledge these bounds before discussing specific studies.

Conceptual Framework

The Province of British Columbia extends over 950,000 square kilometers encompassing a diverse physiography, climate, flora and fauna. The diverse flora is a product of the rugged topography oriented perpendicular to the prevailing winds; of the 8 broad forest regions described for all of Canada [Rowe, 1959], 5 are present in British Columbia. The resultant diversity of vertebrate fauna and its heavy dependency upon forest cover has been noted by Bunnell and Eastman [1976]. The diversity of forest types and wildlife species precludes specific analyses of the influence of each forest management practice on each wildlife species. Acknowledging this diversity, Bunnell and Eastman [1976] proposed a general model of the changes in major resources required by any wildlife species following complete removal of tree overstory. The resources considered were energy, nutrients, water, temporary shelter (thermal cover, snow interception), habitation, escape cover and space. Because it represents a general pattern resulting from autogenic, secondary succession the model can be used as a framework to examine influences of particular forest management practices on wildlife species. The values of the model are that it provides a device for relating scattered observations on many wildlife species in many forest types and offers a vehicle for extrapolating generalities to areas that have not been studied extensively. Its disadvantages are twofold: 1) it is highly empirical and therefore limited in its ability to anticipate effects of forestry practices that have not yet

been applied, and 2) our faith in generalities is waning, and we are attempting to develop a more explicit approach to designating key factors controlling wildlife populations [Bunnell and others, in press].

The relevance of the conceptual framework [*sensu* Bunnell and Eastman, 1976] to the present discussion is that, although not published until 1976, the framework was implicitly incorporated into the recent studies of black-tailed deer (as well as *Cervus canadensis nelsonii*, *C.c. roosevelti*, and *O. virginianus*). The major requirements of deer were considered in terms of their availability during succession. The animal was viewed as an energy and nutrient "transducer," receiving energy and nutrients from the range system and transforming these into animal tissue. Effects of forestry were considered as they altered the rate of production and form of packaging of the energy or nutrients.

All research was embedded within this broad conceptual framework, but it also shows a strong historical development which also should be acknowledged.

Historical Development

There was a long hiatus between the first evaluation of black-tailed deer and its range on Vancouver Island [Cowan, 1945] and subsequent study [for example Gates, 1968; Smith, 1968]. During that period, management of the species considered only harvest policy. Supportive data were acquired from "harvest questionnaires" mailed to hunters and roadside game checks. These seminal studies of black-tailed deer in British Columbia all were pursued in the Coastal Douglas Fir Zone [*sensu* Krajina, 1965]. When Gates and Smith began their studies it was postulated that, in the absence of wildfires and prior to development of the logging industry, few black-tailed deer lived in the moist coniferous forests of the Pacific Northwest [Cowan, 1945; Leopold, 1950; Dasmann and Hines, 1959; Brown, 1961]. Favourable responses by blacktails to the creation of early seral stages were attributed to the improved nutritional quality of the range [Stoner, 1932; Cowan, 1945; Einarsen, 1946; Leopold, 1950; Dasmann and Hines, 1959]. It followed that the largest deer populations could be expected when the numbers of ideal food-producing units for each season were at a maximum. Studies of quality and quantity of forage, as related to numbers of black-tailed deer, were then limited to works by Taber and Dasmann [1958], Dealey [1959], Brown [1961], and Klein [1965]. These investigations documented conditions on separate ranges of different biological or seral structure, and demonstrated biological differences in isolated herds. Accordingly, Gates [1968] chose to measure, in a single system, the nature of changes in vegetation growing in logged and burned areas and to relate these changes to the pattern of range selection by black-tailed deer. Smith [1968], working in the same area as Gates, chose to relate the changing seral conditions to numbers, condition and age-class structure of the herd. Gates concluded "that quality and quantity of food are the primary factors governing range selection by blacktailed deer with protective cover secondary" [Gates, 1968:87]; Smith concluded that "the most important regulatory mechanism for Vancouver Island deer populations (was) seral succession, with regulation accomplished by any combination of hunting, normal miscellaneous mortality, and winter mortality" [Smith, 1968:119].

By the late 1960s, intensive logging had progressed into the northern areas of Vancouver Island which experiences heavier snowfall than previous study areas. Results from earlier studies were assumed to be of limited applicability and research was initiated by Willms [1971] in the north-central portion of Vancouver Island. Willms evaluated the influence of environmental factors (forest edge, elevation, aspect, site index and roads) on deer use of logged and forested lands. His work suggested the importance of mature forest to deer in the Coastal Western Hemlock Zone

[sensu Krajina, 1965], a suggestion subsequently supported by studies of Jones [1974, 1975]. About this time, another dimension was introduced to the management activities of the British Columbia Fish and Wildlife Branch. Cutting plans developed by the forest industry were referred to the Branch via the British Columbia Forest Service for evaluation. Both harvest policy and habitat preservation became part of the management repertoire. Two consequences emerged: 1) the derivation of key factors controlling deer populations in different systems became much more important, and 2) there was considerable economic pressure to infer capability of range quickly and thoroughly. Subsequent studies became increasingly focussed on key factors of deer-range relations. Their focus, however, was directed largely to discerning the significance of mature forests. This focus was consistent with the newly acquired management capability of the major funding agency (British Columbia Fish and Wildlife Branch), that of preserving mature forest from logging. Relatively little work was implemented on deer-range relations within managed forests. The work which is directed towards second-growth forests is sponsored primarily by the forest industry.

Current Research on Deer-Forest Relations

The research presented here is a product of the conceptual framework and historical development reviewed above. It has two major thrusts--computer simulation modeling and field research. The objective of the modeling is to provide a vehicle for integrating the separate studies, to make ongoing research more efficient through this integration, and to help guide management decisions relating to forested lands. The models are developed with specific questions in mind--from detailed bioenergetic questions to the "optimal" spatial and temporal patterns of logging activities. The modeling efforts are treated only superficially for they are merely a tool, albeit a powerful one, for effectively implementing research.

The field research explicitly assumes that we are interested in the production of black-tailed deer as this production is influenced by forestry practices. The variable of predominant interest is, thus, changes in the population of black-tailed deer (ΔP). We can express the net change as a tautology:

$$\Delta P = \text{immigration} - \text{emigration} + \text{births} - \text{deaths} \quad (1)$$

In practice, correlative or causal relations between forest attributes and deer attributes have been explored by examining the influences of forestry practices upon ΔP; much less attention has been directed to the specific rates producing ΔP. There are several reasons. First, considerable information was available on natality and mortality schedules of black-tailed deer [Taber, 1953; Taber and Dasmann, 1954 and 1958; Klein and Olson, 1960; Brown, 1961; Klein, 1965; Smith, 1968; Thomas, 1970]. Second, our review of this information (for example table 1) documented enormous variability in observed measures and indicated considerable difficulties in interpretation of such measures once acquired [Caughley and Birch, 1971; Caughley, 1974; Bunnell and Tait, in press; Tait, manuscript]. Third, careful scrutiny of the British Columbia Fish and Wildlife Branch's method of collecting and interpreting harvest data indicated it was potentially and dangerously misleading; we would have to develop new methods of data collection.

Acknowledging these problems, the major thrust of the research became that of relating changes in deer density to changes of range condition with energy and nutrients (primarily nitrogen) as the major currencies. To develop correlative relations between forests and deer we needed accurate estimates of both deer abundance and range

Table 1. Sex and age class composition of selected populations

Reference Number	Local Distinctions	Sex	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
# 3		M											
		F	?	.30	.21	.15	.09	.08	.06	.03	.02	.02	.01
# 4		M											
		F	?	.23	.18	.28	.09	.05	.02	.04	.00	.07	.04
# 6	Shrub-land	M	.55	.15	.13	.05	.03	.03	.02	.02	.01	.01	
		F	.34	.16	.13	.11	.08	.06	.04	.03	.02	.02	+.01
	Chaparral	M	.36	.17	.14	.09	.06	.05	.04	.04	.03	.02	
		F	.22	.14	.13	.11	.10	.08	.07	.06	.05	.04	
# 6	Shrub-land	M	?	.34	.29	.11	.07	.06	.05	.04	.03	.02	
		F	?	.24	.20	.16	.12	.09	.07	.05	.04	.03	
	Chaparral	M	?	.27	.21	.13	.09	.08	.07	.07	.05	.03	
		F	?	.17	.16	.14	.13	.11	.09	.08	.06	.05	.01
#12		M	.69	.115				.195					
		F	.40	.09				.51					
#14		M & F	.22	.17	.15	.13	.11	.09	.06	.03	.02	.01	.01
		M & F	?	.21	.19	.17	.14	.12	.08	.04	.02	.01	.01
#16	1954-1959	M	?	.453	.206	.152	.076	.113					
		F	?	.316	.205	.160	.117	.202					
	1960-1966	M	?	.398	.221	.173	.109	.099					
		F	?	.303	.221	.165	.107	.204					

#3 Black-tailed deer; Northwest Bay, Vancouver Island; 1963-67; hunted populations; specimens from hunter kill and personal collection aged by tooth sectioning; 5 year average.

#4 Mule deer; Ruby Butte, Nevada; 1967-71; hunted population; specimens collected, aging method unknown but some animals trapped; known age.

#6 Black-tailed deer; California; 1949-55; hunted population; field collection of carcasses aged by tooth eruption and wear (i.e., age at death).

#12 Black-tailed deer; Alaska; 1952, 1954-56; hunted population; field collection of carcasses aged by tooth eruption and wear.

#14 Black-tailed deer; Tsitika-Schoen, Vancouver Island; unhunted population; 1971, 1973, 1974; field collection of carcasses aged by tooth sectioning.

#16 Black-tailed deer; Northwest Bay, Vancouver Island; hunted population; 1954-66; hunter-killed samples aged by tooth eruption and wear.

Continued

Table 1. Sex and age class composition of selected populations (continued)

Reference Number	Local Distinctions	Sex	Age range, in years-- 11-12	12-13	13-14	14-15	15-
# 3		M					
		F	.01	.005	.005	.01	
# 4		M					
		F					
# 6	Shrub-land	M					
		F					
	Chaparral	M					
		F					
# 6	Shrub-land	M		M:F Ratio	54:138 OR	39:100	
		F					
	Chaparral	M		M:F Ratio	60:131 OR	43:100	
		F					
#12		M					
		F					
#14		M & F	.00	.00			
		M & F	.005	.005			
#16	1954-1959	M		M:F Ratio	335:332 OR	101:100	
		F					
	1960-1966	M		M:F Ratio	724:673 OR	108:100	
		F					

condition. To monitor effect of a particular range treatment upon the deer population, we also required some estimate of mortality factors that occur largely independently of range conditions, for example, hunter harvest.

Measures of deer abundance and harvest--The two most commonly employed methods of estimating deer abundance are pellet counts and roadside counts. The effectiveness of both of these methods can be evaluated. In the moist Pacific Northwest it is virtually impossible to distinguish "fresh" from "old" pellets; it is also time-consuming to clear pellet plots. We have evaluated both rates of pellet degradation of individual pellets and reduction in visibility of pellet groups using an 8 cell factorial design [Harestad and others, in preparation]. The design has 2 levels in each of 3

factors, viz. moisture (wet, dry), substrate (vegetated, bare), overstory (forest, slash). The dominant influence was that of moisture, but presence of understory vegetation was also important.

In general, pellet persistence was least in the wet, vegetated, forest sites and greatest in the dry, bare, slash sites. After 1 year, the mean numbers of pellets remaining in the pellet groups on wet sites were between 16 and 48 percent of the original complement of pellets. On the dry sites between 50 and 70 percent of the pellets were present after one year. After 2 years in the wet, slash areas between 1 and 10 percent of the pellets were present, while on the dry, slash sites 20 to 41 percent of the pellets remained.

Similar trends were found in the visibility of pellet groups. On wet sites, 10 to 75 percent of the pellet groups were visible after 1 year, while on the dry sites, 60-95 percent of the pellet groups were visible after 1 year. After 2 years, 5 to 25 percent of the pellet groups on the wet, slash sites were visible, while 25 to 75 percent of the pellet groups on the dry slash sites were visible. There was no significant observer effect on estimated visibility.

Extrapolation of the rates of change of the pellet group visibilities indicate that on wet sites the number of pellet groups counted represent between 100 and 200 percent of the actual number of pellet groups deposited during the previous year. Black-tailed deer pellet group counts conducted on uncleared plots are likely overestimates of population density and habitat use. These overestimates could range from 0 to 3 times their actual value. Thus, population indices from different areas could differ up to 3 times and still represent the same actual population density.

The rates derived from the studies allow more reliable interpretation of past results and extension of present findings. It is noteworthy that pellet counts calibrated by degradation studies give estimates of deer abundance in close agreement with Jolly-Seber estimates using marked animals and roadside counts.

Roadside counts also present a dilemma, even when we recognize the fundamentals of sampling theory and effectively reduce variance in counts by stratifying by habitat type and time of year. A fixed level of sampling effort (distance driven) must be allocated over both the length of individual transects and number of individual transects. The dilemma is simple: variance in night counts decreases with increasing transect length; at a fixed effort, increase in transect length reduces the number of transects counted; a decrease in number of counts increases the variance. Here, too, we can evaluate our methodology [Harestad and Jones, in preparation]. The optimum sampling regime occurs where the first derivative of the variance with respect to number of transects (ds), equals the first derivative of the t distribution at some level of confidence (dt, at perhaps $\alpha = .05$); that is ds = dt. The function $|ds-dt|$ can be evaluated for a given sampling effort E. Because length of transect (L) and number of transects (n) are not independent ($E = nL$), determination of n from the function $|ds-dt|$ also specifies the optimal length.

As noted above we also require estimates of deer harvest to have confidence in our measures of abundance. Attempts to evaluate effects of a particular management practice require harvest data from the specific area. While the structure of the problem is clear, incorporate smaller management units, the mechanism is less clear, particularly when large numbers of game checks are prohibitively costly and a mail questionnaire must be relied on for the bulk of the data. The major problem with questionnaires is that they assume questionnaire respondents are representative of all holders of hunting licenses. This gross assumption can be avoided, at least in part. Since 1975, hunting licenses held on Vancouver Island have been cross-referenced to hunter questionnaires and license numbers have been recorded for hunters contacted in the field or at game checks. Mark-recapture techniques can be used to estimate game

harvests from field contacts (marking phase) and questionnaire returns (recapture phase). The evaluation that has been performed suggests that the mark-recapture estimates are much more accurate than questionnaire returns alone [Kale, in preparation].

Research on pellet group persistence, night counts and harvest patterns was implemented to increase our confidence in estimates of deer abundance and ΔP. Of the factors in Equation 1, only emigration has been treated directly. Tags were recovered from 66 of the 229 fawns ear-tagged between 1959 and 1964 at Northwest Bay, Vancouver Island [Harestad and Bunnell, manuscript]. The furthest distance moved was 32 kilometers by an unsexed deer, 1-1/2 years old when killed. The second furthest movement was by a 1-1/2 year old female that moved 30 kilometers. Analysis of the distances between tagging and recovery sites, and the ages at which the deer were killed, indicates that close to one-half (45 percent) of the males and one-sixth (16 percent) of the females move further than 5 kilometers from their tagging site and so presumably from their birth site. Comparison of these data with those recalculated from Brown [1961] indicate that almost 2 times as many males moved distances greater than 5 kilometers in Northwest Bay than did males in Washington. This difference in male emigratory rate may be explained by density dependent emigration. In Northwest Bay the estimated deer densities were between 17 and 72 percent greater than those in Washington. Two-thirds of the movements greater than 5 kilometers occur when the deer are between the ages of 1 and 2 years. The high emigration rates observed in black-tailed deer could have substantial effects on the measurement of population variables and harvest rates, especially when these values are determined in relatively small study areas.

Immigration rates of Equation 1 can be assumed equal to emigration rates only where densities are relatively homogeneous. Birth and death rates (other than harvest) have not been estimated directly. Carryover counts, which can be evaluated in the same manner as night counts, have been employed. Reproductive tracts and jaws have been collected (table 1), but are not a major component of the research.

Deer-forest relations--The preceding discussion has noted some means we have utilized to increase our confidence in estimates of deer abundance. The majority of the research effort has been directed towards documentation of daily, seasonal and longer-term responses of the deer (movements and abundance) to changes in the forest environment. It is clear that different factors exert varying degrees of control on Columbian blacktails in different forest zones (fig. 1). To address this complex issue, I will limit discussion largely to the Western Hemlock Zone, note first deer movements within the zone, discuss particular environmental controls, then briefly mention impacts of some forestry practices.

Deer movements. Harestad [in preparation] has noted that during the spring a few deer move from the wintering areas into the higher elevations and non-wintering areas almost as soon as the snow pack has melted. However, the bulk of the deer remain in the lower elevations and do not migrate until much later. By mid-April some of the deer have moved into the mid-elevations. By mid-June and early July, many deer have moved into the higher elevations. After the first snows, which occur in late October and early November, the densities of deer in the high- and middle-elevations drop.

The mean size of home ranges of males in the spring is 50 hectares, significantly larger than the female home ranges at this time of 10.4 hectares. The summer home ranges are much larger than the spring home ranges. In males, the summer home range size is 175 hectares while that of the females is 40 hectares. In winter the home ranges collapse in size but in general, remain larger than the spring home ranges. As with spring and summer home ranges, the winter home range size of the males (84 hectares) is larger than that of the females (32 hectares).

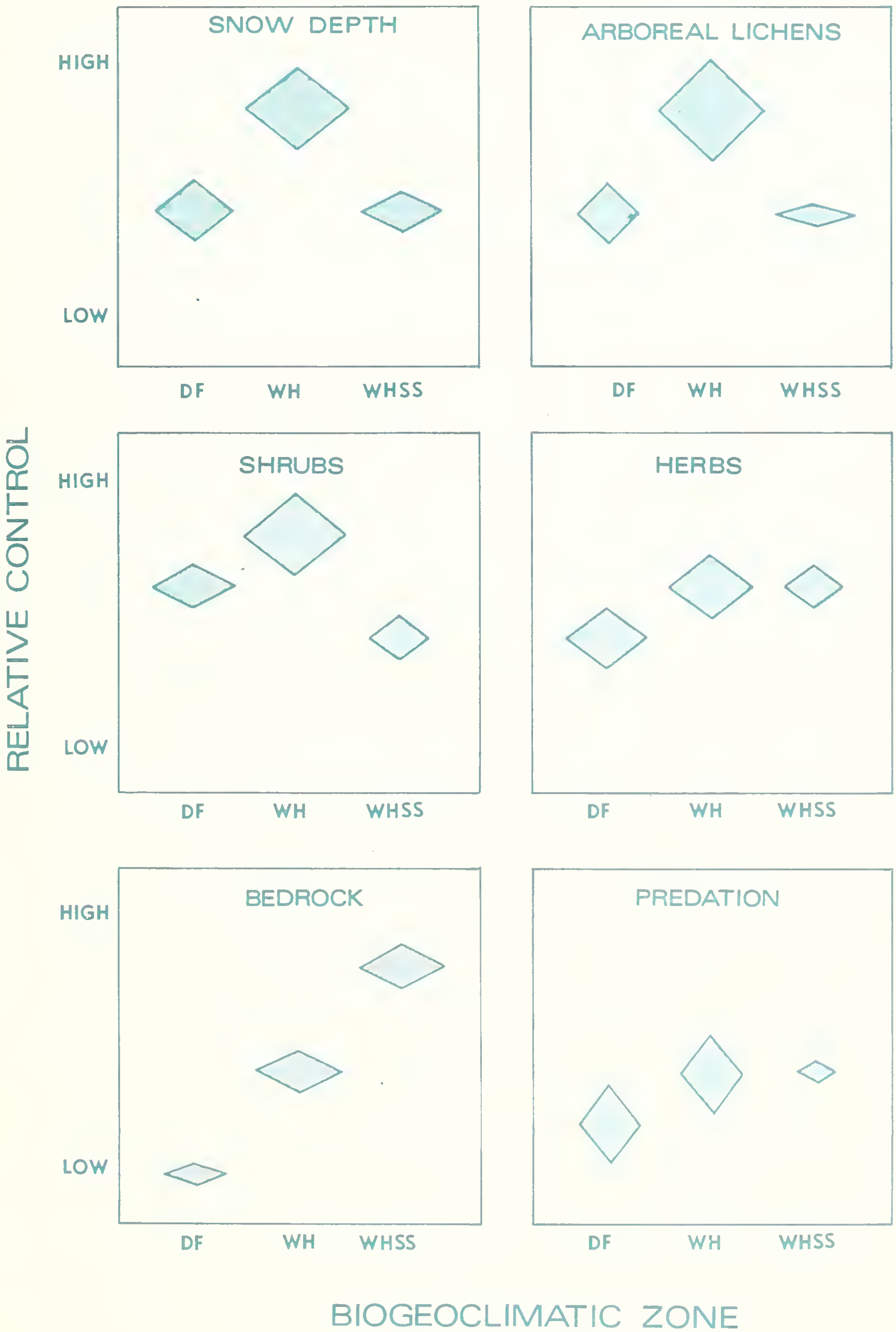

Figure 1. Key factors controlling numbers of blacktailed deer in different ecosystems. Width of the diamonds represent relative confidence in the quality of information available; height represents relative confidence in the quantity of information. Legend for ecosystems: DF=Douglas Fir Zone, WH=Western Hemlock Zone, WHSS=Fog Western Hemlock/Sitka Spruce Zone. All sensu Packee 1976.

There is wide variation in the locations of the seasonal home ranges with respect to one another. In some deer, their spring range is immediately next to their winter range whereas in other deer the spring range is between the winter and summer ranges. Mean distances between the centers of the seasonal home ranges are: spring-summer, 3 kilometers; summer-winter, 2.8 kilometers; and winter-spring, 1 kilometer. The maximum distance migrated by a radiotagged deer was 6.4 kilometers and occurred between its spring and summer home ranges. Another deer shifted its center of home range by only about 0.5 kilometers during each of the seasons. Typically, the summer home ranges were located at higher elevations than were the winter and spring home ranges. In most instances, the spring home ranges were located in the valley bottom areas adjacent to the winter home ranges.

Harestad [in preparation] hypothesized that the observed patterns of seasonal movements were in response to seasonal changes in food availability. To test this hypothesis food abundance was measured in each of the seasonal home ranges. Contributions to the food supply were estimated for *Vaccinium parvifolium*, *Vaccinium alaskaense*, and *Gaultheria shallon* by measuring the numbers and the heights of the shrub stalks on representative plots in the home ranges. These numbers and heights were then converted to kilograms of annual growth per hectare through the use of crown-stalk height and annual growth-stalk height regressions. The abundance of *Alectoria* was estimated through low level oblique aerial photographs of the forest crown above the plots.

In general, the deer inhabited those areas where food was most abundant during that season. The apparent objective of maximizing food abundance results in different seasonal movement patterns. Some deer made vertical migrations, others made horizontal migrations, while still others just shifted their intensity of use of forest and logging slash. In all cases, the result was to maximize food abundance.

Environmental controls: deer forage. It is apparent from fig. 1 that availability of forage plants (particularly arboreal lichens and shrubs) is assumed to be controlling deer abundance in the Western Hemlock Zone. The role of snow in modifying availability is discussed later. Harestad's work documents the response of the deer population to levels of forage; the work of Ellis, Rochelle, and Stevenson extends the manner and degree of control.

Rochelle [in preparation] continued the evaluation of food habits initiated by Jones [1975], but dealt more intensively with deer-forage relationships. In particular, he has documented monthly changes in chemical composition of ten major forage species and related these to such measures as rumen nitrogen, dry matter digestibility, and production of volatile fatty acids. Plant samples were collected from both mature forest and recently logged areas. Thus, we can document the patterns of metabolizable energy and nutrients available within these two broad types. These patterns are in turn related to animal condition through such measures as blood urea nitrogen, mesentery fat, etc. One outcome of the work of Rochelle [in preparation] was documentation of the significance of arboreal lichens. It was apparent from studies in the Douglas Fir Zone [Cowan, 1945; Gates, 1968] and the Western Hemlock Zone [Jones, 1975] that Columbian blacktails consume large amounts of lichen in the winter and spring. The more detailed measures of Rochelle provided additional information. First, for deer collected in the timber, arboreal lichen was the second most common constituent of the diet (35.5 percent

by volume; 100 percent frequency; n = 12). All other species with the exception of *Gaultheria shallon* occurred at volumes of less than 5 percent. Second, winter litterfall of lichen on winter ranges is approximately equal to the production of rooted forage, 40-150 kilograms per hectare. Third, the major constituent of the litterfall (*Alectoria* spp.) has an *in vitro* dry matter digestibility of 75-90 percent, about 35-40 percent higher than the digestibilities of key rooted species *Vaccinium parvifolium*, *Thuja plicata*, and *G. shallon*.

As a result of these findings, more detailed research was conducted on the *Alectoria* component of black-tailed deer forage. Stevenson [in preparation] extended Rochelle's studies of lichen litterfall and consumption of litter, and evaluated means of estimating lichen abundance. The exclosure plots of Stevenson corroborate results of Rochelle; even in mild winters black-tailed deer consume about 50 percent of the lichen litterfall in areas of high snow fall. Her evaluation of visual and aerial photographic (large scale infrared) estimates of lichen abundance has provided a useful tool for range assessment. The two techniques were evaluated by handpicking lichens from selectively fallen trees. Using the sampling scheme she developed, visual estimates of lichen abundance predict biomass (kilograms per hectare) with reasonable accuracy (r^2 = 0.74 to 0.90 [Stevenson, in preparation]).

The work of Jones, Rochelle, and Harestad also indicated the importance of the shrub component of winter and spring ranges. Shrub productivity on winter-spring ranges appears a major factor controlling blacktail numbers in some forest types (fig. 1). As the forest industry has been experiencing economic difficulties, the reservation of low elevation "winter logging shows" as blacktail winter range has become increasingly conflict-laden. The work of Ellis [in preparation] was initiated to extend evaluations of carrying capacity in timbered and adjacent cutover areas. This work is currently underway and has the following objectives:

1) To determine carrying capacity of the winter-spring, shrub range complex. Methods are directed to examination of the impact of browsing on the growth and competitive status of key shrub species and consequent growth patterns generated by browsing.

2) To determine mineral dynamics associated with the biomass and population dynamics of Objective 1. Changes in mineral concentrations are being examined during early successional stages and fertilization experiments.

Integration of the work of Jones, Rochelle, Harestad, Stevenson and Ellis should document the manner and degree of control exerted on blacktails by forage availability.

Snow. Despite the relatively low track loading (211 to 352 grams per square centimeter), the short chest height of black-tailed deer (44 to 59 centimeters depending on sex and age class) seriously curtail movement in snow greater than 60 centimeters. As crusting conditions are relatively infrequent over much of the range of black-tailed deer, accumulated snow pack is a significant factor delineating deer range in terms of both deer mobility and food availability. Mean annual snowfall within black-tailed deer range varies from 25-107 centimeters to 12.7-750 centimeters depending on biogeoclimatic zone; thus, the

importance of snowfall as a factor controlling deer numbers varies (fig. 1). In regions of high snowfall where snow pack is likely to exceed either chest height or mean height of rooted forage, closure of the mature tree canopy becomes an important factor determining the value of the range. On higher elevation winter ranges (about 800 meters above sea level), snow pack frequently attains depths of 180-200 centimeters in open areas, 110 centimeters in areas which support 30 percent crown closure and only 30 centimeters in areas of 70 percent crown closure [Jones, 1975].

In those areas where snowfall is liable to become a controlling factor, mean shrub height is important in evaluating the value of range as well as canopy closure. Both Harestad and Ellis have documented good predictive relations between shrub height and productivity.

Predation. As is evident from fig. 1, we are still uncertain about the effects of predation on black-tailed deer numbers. It is, however, apparent that wolves, cougars, blackbears, and even golden eagles are taking fawns. The Dewars, working with British Columbia Fish and Wildlife Branch in Nanaimo, have radio-collared more than 20 cougars but, to date, most of the data are unanalyzed and we know little more than the cougar is an efficient predator on deer. Information on wolves is equally cursory. The preliminary evaluations of wolf predation suggest that deer recruitment may be reduced by 40 percent in areas where wolves are abundant. Wolf numbers appear to be increasing. In areas where dense wolf populations and heavy hunting pressure coincide, the effects on deer populations appear significant, but conclusions are again premature. Scott is beginning more definitive studies on the Vancouver Island wolf.

Bedrock geology. Some controls on deer numbers are more indirect than those of snow depth or predation. The British Columbia Fish and Wildlife Branch has delineated "deer production capability zones" for Vancouver Island. These zones show only modest correlation with the biogeoclimatic zones for the area proposed by Krajina [1965] and refined by Packee [1976]. Deer abundance does, however, correlate well with the andesitic till soils underlain by Bonanza Group rocks. Andesitic soils are generally higher in nutrients, particularly nitrogen, than are tills overlying other bedrock types [Lewis, 1976]. Further, levels of nitrogen in key forage species frequently fall below 7 percent on other soils. As there was little redistribution of parent materials during glaciation of Vancouver Island, the correlation between deer production and underlying geology is not surprising.

As with other potential controls on deer numbers the effect exerted varies between biogeoclimatic zones (fig. 1). We presently assume that bedrock geology exerts its greatest control in the Fog Western Hemlock/Sitka Spruce Zone. Over much of this zone other potentially controlling features appear of less importance, and superficial appearances suggest the zone should support large numbers of deer. By recognizing such broad correlations as those between deer abundance and bedrock geology, management goals that would ultimately be constrained by fundamental controls can be rejected at the outset.

Inputs of forestry practices--Bunnell and Eastman [1976] presented a general model of the impacts of forestry practices upon wildlife. Over the past two years, efforts have been directed to enhancing the predictability and utility of that model. One approach has been to refine our derivation of controlling factors [Bunnell and

others, in press]. For example, even though the Fog Western Hemlock/Sitka Spruce Zone appears capable of supporting high deer densities, it might prove futile to place severe restrictions on forestry practices in the zone because deer numbers will remain indirectly constrained by bedrock. Major research efforts now are being directed towards predicting changes in successional patterns accompanying intensive forestry practices, documenting more clearly tree-ungulate-snow relations, and addressing the question of "green-up" periods, the time left between adjacent cut blocks. We can consider the latter question to exemplify the approach.

Earlier studies have examined the response of blacktail use to either different seral stages [Gates, 1968] or to different sizes and shapes of clearcuts [Willms, 1971]. These studies thus treat either the spatial or temporal dimension of deer use. Some have interpreted the results of Willms' study (for example figs. 2 and 3) to suggest that clearcuts should not be greater than 1600 feet (485 meters) in width if maximum deer numbers are to be supported. Maximum sizes of clearcut blocks would thus be 23.5 hectares (58 acres). As well as the obvious geometric fallacy, it is apparent that studies dealing with only the spatial or temporal dimension cannot be extrapolated so simply; both the temporal and spatial dimensions must be considered simultaneously. At present, the most effective approach appears to be conditional simulation models examining the effects of documented dispersal patterns when these are invoked within different cutting patterns. Research here is still preliminary. We have also invoked the approach used for roe deer in Poland.

Bobek [1977] reported reasonable success relating the abundance of roe deer to areas of different seral stage in Polish forests. Unlike roe deer, blacktails are not highly territorial, but do show strong associations with particular seral stages. Our initial model was of the form

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 \tag{2}$$

where Y = a measure of deer abundance or use,
X_1 = area or proportion of total area in age class 1-5 years,
X_2 = area or proportion of total area in age class 6-10 years,
and X_3 = area of proportion of total area in age class 11-20 years.

In the simple linear formulation of Equation 2, the values for r^2 are low (0.25-0.35). The inclusion of interaction terms has a sound biological rationale as the availability of food (X_1) without shelter (X_3), or vice versa, will affect the population differently than if they were in optional proportions. Inclusion of interaction terms increases the values for r^2 to 0.94-0.96, highly significant. These results also are preliminary, for two reasons. First, only a small portion of the available data has been examined. Second, the form of the equation cannot be vested with clear biological meaning. As a means for relating gross impacts of timber management on black-tailed deer range such equations may be highly predictive over the range of data collected, but as the form of range manipulation changes (for example more intensive forestry) such equations likely will lose their effectiveness. Measures more directly related to features of the range are required. In part, such measures are being acquired (Ellis, Harestad, Rochelle, Stevenson) but we are still exploring models that will predict effectively the impacts of forestry practices on the deer.

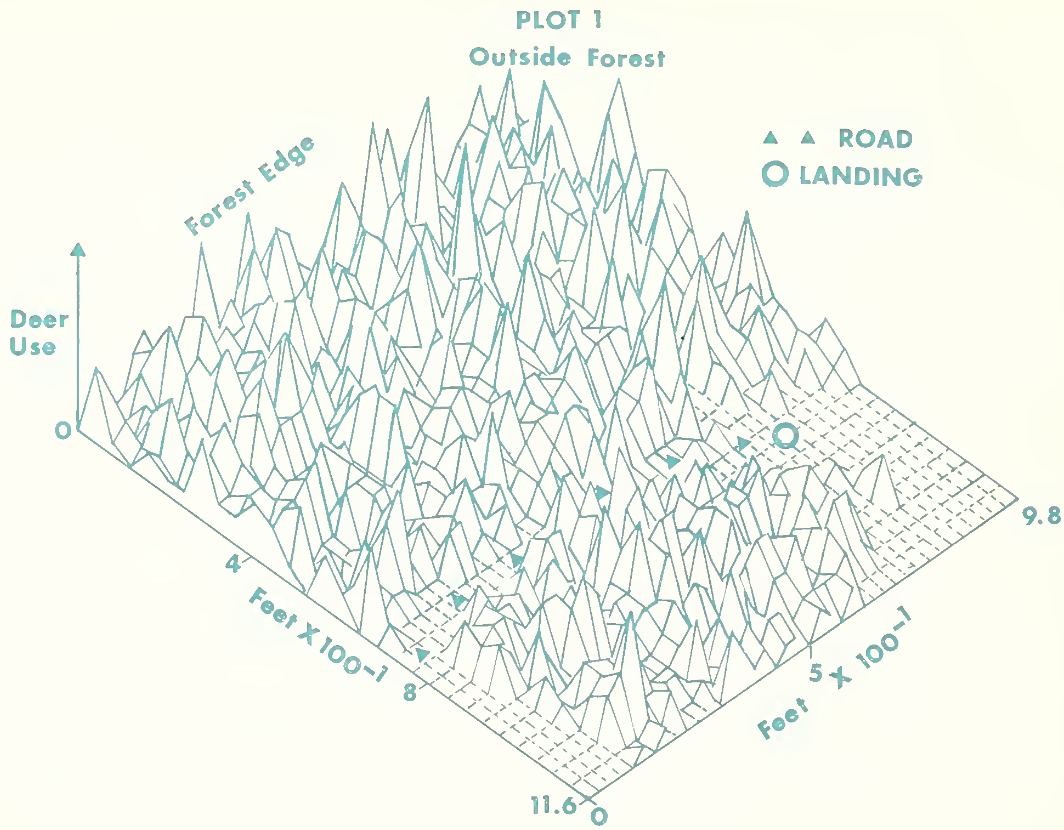

Figure 2. Pellet group distribution on a southern exposure and a 1961 burn.

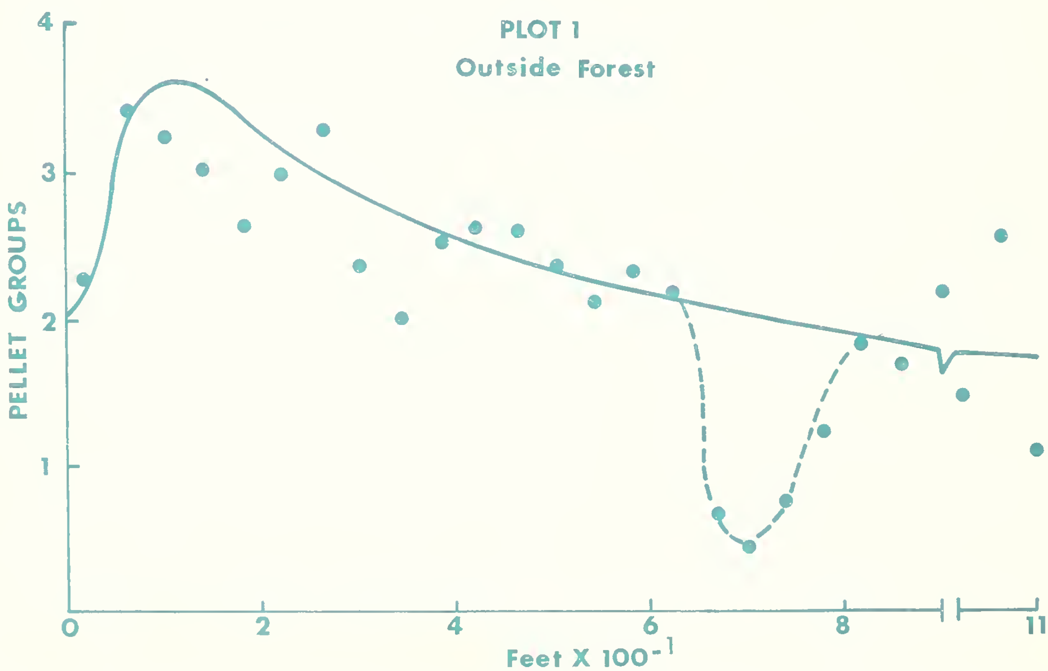

Figure 3. Effect of upper forest edge on deer use of a southern exposure logged and slashburned in 1961. Broken line indicates effect of road use on deer use.

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Appendix I

Individuals at the University of British Columbia Pursuing Deer-related Studies on Vancouver Island

Rick Ellis
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Subject:
Biomass, nutrient and population dynamics of shrubs; exclosure and fertilizer studies.

Alton Harestad
Faculty of Forestry
University of British Columbia
Vancouver, B.C. Canada V6T 1W5

Subject:
Dispersal of deer including factors involved in habitat selection.

Wayne Kale
Department of Animal Science
University of British Columbia
Vancouver, B.C. Canada V6T 1W5

Subject:
Refinement of deer harvest statistics, including hunter effort; deer-habitat relations.

Jim Rochelle
Weyerhaeuser Co. Ltd.
P.O. Box 420
Centralia, Washington 98531 U.S.A.

Subject:
Nutrient dynamics of forage, *in vitro* digestibilities, VFA production, animal condition measures.

Barbara Scott
Department of Animal Science
University of British Columbia
Vancouver, B.C. Canada V6T 1W5

Subject:
Food habits, population dynamics, and social organization of Vancouver Island wolves.

Susan Stevenson
S.S. #1, Site 5
Cranbrook, B.C.
Canada V1C 4H4

Subject:
Taxonomy and ecology of forage lichens, lichen litterfall, methods of quantifying lichen abundance.

The Influence of Timber Harvest on Yield and Protein Content of *Vaccinium* Browse on Three Dominant Soil Types in Southeast Alaska[1/]

by

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and

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Introduction

Beach fringe and low elevation timbered areas of Southeast Alaska have traditionally been under great logging pressure because of their easy accessibility and high quality timber. However, these areas are also critical deer winter range and the habitat they provide is essential to maintain deer through the months of heavy snowpack [Merriam, 1971a]. Previous studies have shown that quantities of browse species increase considerably in areas opened by recent logging [Robinson, 1958; Billings and Bishop, 1971; Telfer, 1971, 1974; Patton, 1974]. Unfortunately, in southeast Alaska, especially the northern half, this browse is often buried by snowpack during the winter, restricting deer to the remaining lower elevations, climax timbered stands. Quantitative information is presently lacking on the impact of clearcutting on forage production in the climax forest. A better understanding of this impact is necessary to design cutting units which will maintain or improve rather than damage critical deer habitat.

Studies have been conducted throughout the United States to determine the quantity and quality of forage produced on unlogged deer range [Einarsen, 1946a, 1946b; Dietz and others, 1962; Brown, 1961; Dietz, 1965; Short and others, 1969; Alldredge and others, 1974; Hickman, 1975]. These studies, in addition to those by McEwen and others [1957] and Ullrey and others [1971], have resulted in well-established estimates of optimal intake rates on a dry weight and percent protein content basis for

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2/ At the time this article was written, the authors were, respectively, Soil Scientist and Biological Aid for the U.S. Forest Service, Tongass National Forest, Region 10, Alaska.

maintenance of deer. Most studies [French and others, 1955; McEwen and others, 1957] assess minimal average annual protein levels necessary to maintain growth. No studies were found which tested for minimal intake rates and protein contents necessary to sustain deer through the critical winter months until they can return to more nutritive and abundant spring and summer foods. Some data indicating variation in quality and quantity of forage in response to stage of vegetative succession have been reported within the range of black-tailed deer (*Odocoileus hemionus*) [Einarsen, 1946; Robinson, 1958; Brown, 1961]. However, we are not aware of any investigations of forage response to increased available light within a stand due to adjacent artificial stand openings. In Southeast Alaska, however, marginal winter habitats that consist of extremely homogeneous cover types must be closely examined to determine any manageable factor that may influence forage production.

Although several studies [Klein, 1963, 1965; Abell and Gilbert, 1974] have indicated that soils may significantly contribute to the observed variation in forage quantity and quality, few have directly tested the influence of soils [Hundley, 1959; McCaffery and Creed, 1969]. Klein [1963], in an extensive study of physiological responses of Sitka black-tailed deer to different quality forage in southeast Alaska, stated that soils were probably of less consequence in determining forage quality than were altitude, exposure and cover type; but his work was based primarily on summer range habitats which included a wide variety of these factors. Winter range is essentially restricted to forested habitats at low elevations. It would, therefore, seem likely that soil type may play a very important role in the quantity and quality of forage produced on an otherwise relative homogeneous winter habitat.

The objectives of this investigation was to determine the effects of timber harvest and soil type on quantity and quality of deer forage produced at the edge[1/] of residual forest stands.

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Methods and Materials

Soil classification and sites sampled--Significant and predictable differences in timber growth have been observed on different soil series in southeast Alaska [Stephens and others, 1968]. For simplicity of soil classification and forest management recommendations, the existing soil series, along with their representative plant communities, have been grouped into ecosystems [Stephens and others, 1974]. The 3 most common productive forest ecosystems have been chosen for observation in the present study. They are:

1/ The "edge" or "edge effect" are terms used in this paper to define the influence of additional light from natural or artificial openings on forage quantity and quality beneath the adjacent residual stand.

F1 - Moderately well to well-drained, deep (25 centimeters to 1.5 meters), forested mineral soils (Cryorthods).

F2 - Moderately well to well-drained, shallow (5 centimeters to 25 centimeters), forested mineral soils (Cryorthods).

F4 - Somewhat poorly drained, forested mineral soils (25 centimeters to 1.5 meters deep) (Cryaquods; Cryic Fragiaquods).

All future references to these groups in this paper will be as ecosystems.

Quantity and quality of forage were sampled on 18 forested sites bordering clearcut areas. Criteria for selection of these sites included ecosystem classification; age and origin of the opening adjacent to the candidate stand, and the topographic variables; elevation, aspect and slope. Sites that exhibited current browsing of understory plants were rejected.[2/] Six sites were sampled on each of the 3 ecosystems, F1, F2 and F4. Age of these openings ranged from 3 to 12 years. Care was taken to select sites of similar topographic and successional stage.

Sampling design and statistical methods--A fixed sampling design was used to obtain estimates of the amount of forage produced on a site. The design consisted of 4 transects running parallel to the exposed edge of the stand at 1, 50, 100 and 200 feet (15, 30 and 60 meters) from the edge into the residual stand. In turn, each transect contained 4 plots, milacre (.0004 hectares) in size, spaced at 50-foot (15-meter) intervals. Similar sampling methods were used to obtain estimates of forage production in the center of clearcuts, but those data were analyzed separately. Samples were gathered from September 1974 through February 1975.

The current year's forage within milacre plots was separated by species and put into cloth bags. The materials were oven-dried at 70° C for 24 hours and weighed to the nearest 0.1 gram. In early December 1974 and late February 1975, representative samples of *Vaccinium ovalifolium* stem were collected for each transect and in the clearcut opening, ground in a Wiley mill and analyzed for total nitrogen using automated micro-Kjeldahl methods. Nitrogen levels were multiplied by the factor of 6.25 and expressed as percent crude protein [Klein, 1963; Abell and Gilbert, 1974]. Nitrogen content was determined for samples of *Vaccinium* on F1 and F4 ecosystems. Total crude protein per unit area was determined by multiplying percent crude protein by total forage dry weight per unit area. Estimates of the gain or loss of *Vaccinium* protein yield as influenced by the size and shape of clearcut areas were calculated using a formula developed from this data.

Blue huckleberry (*Vaccinium ovalifolium*) is the most important and common winter browse species in much of southeast Alaska [Merriam, 1971a, 1971b], occurring in every mature forested ecosystem. Three other species of *Vaccinium* (*V. caespitosum*, *V. alaskaensis*, and *V. parvifolium*) occur less commonly, but are also browsed when present. The current year's growth of all 4 species was collected after leaf fall and combined for total forage quantity estimates. The current year's growth is the most succulent portion of the dormant plant and that most commonly browsed.

2/ Portions of central southeast Alaska are experiencing an extremely low deer population due to a combination of natural cycles coupled with severe winter and heavy wolf predation. This condition has resulted in an abundance of unbrowsed forage plants in key wintering areas, making this study feasible.

Data on quantity and quality of *Vaccinium ovalifolium* browse were analyzed using an analysis of variance for split-plots. Homogeneity of variances between ecosystems was tested. Fixed, main effects tested were ecosystems (whole plots) and edge effect (sub-plots). First-order interaction between ecosystems and edge effect was also tested. Individual comparisons of ecosystems were made orthogonally on previously selected groupings. Four-plot means (average for 4 plots in a transect) were used as individual items in the analyses.

Results and Discussion

Forage quantity--Homogeneity of variances existed between ecosystems. A split-plot analysis of variance for deer forage production (kilograms per hectare per year) showed differences in forage production at the 4 distances measured from the stands' edge were large and statistically significant (P = 0.001). Orthogonal contrasts showed significant differences existing between F1 and F4 ecosystems (P = 0.1). Particularly important is the significance of the first-order interaction between ecosystem and edge effects (P = 0.05).

Figure 1 shows the quantity of *Vaccinium* browse produced in each ecosystem under the influence of edge. Production of browse on F1 and F2 ecosystems, although very high near the edge of a residual stand, falls off rapidly with distance into a stand.

On F4 ecosystems, forage production is much less enhanced by increased light at the edge and decreased more slowly inward. This is probably due to the nature of the stand structure. The F1 and F2 ecosystems have stands with relatively tight, closed canopies (closure of 55 to 85 percent), whereas, the F4 is represented by canopy closures of only 35 to 65 percent. Since canopies are relatively open on F4 ecosystems, any increase in light received from adjacent openings will not have as pronounced an effect on productivity as it will on the other ecosystems.

Absolute values presented in fig. 1 substantiate earlier findings by Stephens and others [1968] that productivity levels are lower on F4s than F1s. Four browse productivity curves are shown in fig. 1: 2 for F4 ecosystems and 1 each for F1 and F2 ecosystems. Values used in curves for F1, F2 and F4(a) were obtained from the fixed sampling design described in this paper. Statistical analyses were performed on these data (tables 1 and 2). Curve F4(b) represents values obtained from 15 additional transects on F4 ecosystems in 1973 and 1975. This curve more accurately represents existing conditions in the field. Restrictions placed on sites sampled to eliminate environmental variables that could not be tested (for example, aspect, slope, etc.), reduced the distribution and variability of sites that could be sampled on F4 ecosystems in the fixed design.

To better estimate productivity, therefore, additional transects were made on all ecosystems. Only the values for F4s were appreciably changed (values for the other ecosystems varied from 5 to 10 percent). Statistically, these values could not be accurately tested. However, to the forest manager dealing with complex environments, the additional values are likely more representative.

Forage quality--Quality of browse varies considerably with season [Einarson 1946a; Dietz and others, 1962; Abell and Gilbert, 1974; Hickman, 1975]. In our study, samples for nutrient analyses were collected in winter and early spring for this is the period when deer have the greatest problems in obtaining an adequate supply of nutritious food in northern latitudes [Brown, 1961]. Protein content of most browse species is lowest at this time of year.

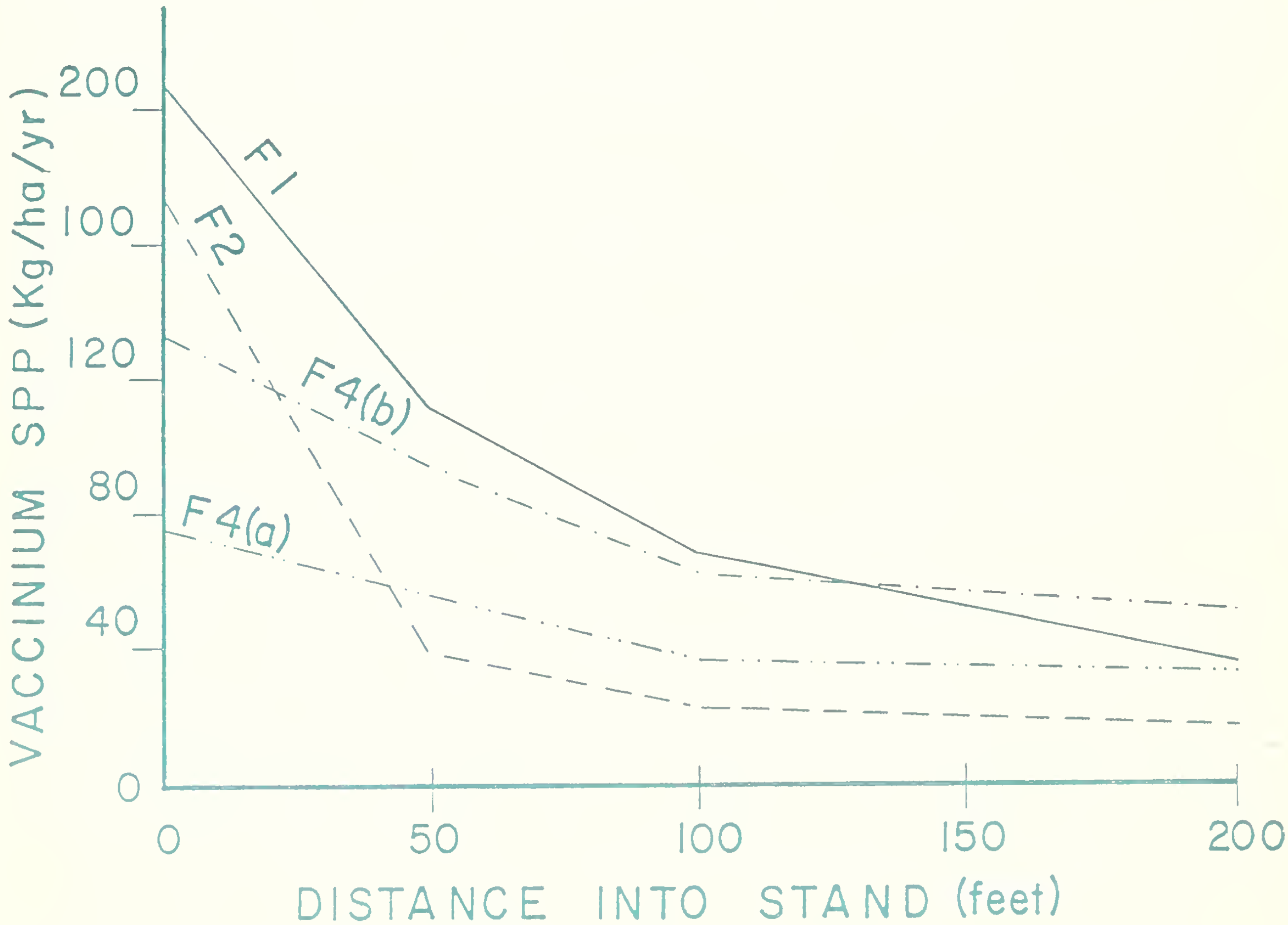

Figure 1. Browse productivity (kg/ha/year) on three soil types as influenced by distance into a stand (feet). Curves for F1, F2 and F4 (a) ecosystems represent observed values from fixed sampling design used in statistical analysis. The curve for F4 (b) represents observed values from 15 additional transects through F4 ecosystems.

Table 1. Split-plot analysis of variance for *Vaccinium ovalifolium* biomass production of 3 ecosystems in southeast Alaska

Source of Variation	Degrees of Freedom	Mean Squares	F Values	Coefficient of Variation
Ecosystem	2	13,091	1.94 ns	
F2 vs F1, F4	1	1,792	.27 ns	
F1 vs F4	1	24,390	3.62*	
Error A	15	6,747		
Subtotal	17			
Edge Effect	3	46,936	8.57***	
Ecosystem x Edge interaction	6	5,474	2.55**	
Error B	45	2,149		
Total	71			51%

*, **, *** indicate significance at the 0.1, 0.05 and 0.001 levels, respectively.

Table 2. Split-plot analysis of variance of protein content of *Vaccinium ovalifolium* (percent of dry weight) sampled in December on two ecosystems in southeast Alaska

Source of Variation	Degrees of Freedom	Mean Squares	F Values	Coefficient of Variation
Ecosystem	1	1,5.76	11.67**	
Error A	6	1.35		
Subtotal	7			
Edge Effect	4	1,0.49	19.42**	
Edge Effect x Ecosystem interaction	4	.54	1.32 ns	
Error B	24	.41		
Total	39			6%

, * indicate significance at the 0.025 and 0.001 levels, respectively.

Although widely used as an indicator, crude protein content is not the only measure of forage quality. Digestibility and cellulose and lignin contents may become increasingly important at low (marginal) protein content levels.

An analysis of variance showed that crude protein content of *Vaccinium* in December varied significantly between F1 and F4 ecosystems (P = 0.025) and among transects within ecosystems (P = 0.001). Similar differences were observed in February 1975 (ecosystems, P = 0.1, transects, P = 0.05). Average crude protein contents are shown in table 3.

The percent protein of the forage has been shown to be a critical factor for the maintenance of deer [McEwen and others, 1967; Ullrey and others, 1971]. Low percentages of forage protein content may require increased periods of browsing and more extensive winter ranges. Einarsen [1946a] hypothesized that black-tailed deer that would normally feed for 7 to 10 hours in mid-summer, could not have maintained the same body weight in January even with 14 hours dedicated to feeding.

Table 3. Average crude protein content (percent) of *Vaccinium ovalifolium* in the open and at 4 distances into residual stands on 2 ecosystems and at 2 periods of the year in southeast Alaska. Values are averages of sample size = 16.

Ecosystem	Distance into residual stand in feet				
	Open	0	50	100	200
F1 December	7.6	5.1	6.4	6.9	8.4
February		6.5	6.7	6.6	8.7
F4 December	8.5	6.6	7.4	8.9	9.2
February		6.2	7.3	8.1	9.1

A preference by deer for the more nutritive browse has been demonstrated by Swift [1948]; however, Longhurst and others [1968] found the relationship between nutritive content and palatability was not always a positive one. Interestingly, Cook [1939] found deer preferred shade-grown sprouts to those faster-growing ones produced after clearcutting. McEwen and others [1957] have reported that white-tailed deer required 7 to 9 percent crude protein in their diets to maintain health. They found that young deer could survive on a year-round diet of 4.6 percent protein; however, they considered the optimum levels of protein to be 13 to 16 percent. These figures are generally accepted by others for white-tailed and black-tailed deer, although Einarsen [1946a] hypothesized that 5 percent protein is the critical low level for maintenance of health. There are few controlled nutrition studies that have shown yearly average protein levels less than 7 percent to be sufficient to maintain deer. However, since deer in southeast Alaska generally have an abundance of high quality browse (16 to 35 percent protein) available during 6 to 9 months of the year [Klein, 1957; Merriam, 1971], a lower protein level during winter months may be tolerable. Our data show that minimal protein requirements are apparently met during critical winter months under all canopy tested on F1 and F4 soils, with the most nutritious forage being found under natural forested conditions of F4 ecosystems. The value of the increased forage biomass at the edge of a stand is partially lost due to the lower protein contents of those plants.

That the highest protein values were observed under mature canopy conditions is significant and contrary to the findings of many previous investigators. Einarsen [1946a] reported that forage growing in clearcuts was more nutritious than that under the canopy, but his values were for areas that had been recently burned. Brown [1961] reported some findings similar to ours. He found protein values for huckleberry (*Vaccinium*) under mature forest conditions higher in two instances than values from areas cut 20 years prior to sampling and, in one case, than values from the open clearcut. The authors cannot clearly explain why higher protein contents occur in vegetation growing under mature canopy conditions. Increased competition with overstory and subordinate vegetation for limited nitrogen resources, as well as dilution effect from more rapid growth of these plants being exposed to light, may be speculated as the cause of lower protein values at the edge of the stand.

Some support for the hypothesis of a dilution effect may be seen in table 3. Vegetative samples taken on F4 ecosystems consistently contained a greater percentage of crude protein than did the faster-growing, more succulent F1 samples. Stephens and others [1968] have shown that F1 soil ecosystems have considerably higher nitrogen levels and site indices for Sitka spruce than F4 ecosystems. This is supported by the total crude protein values (kilograms per hectare per year) calculated in table 4 for browse on the two ecosystems. The less nutritious browse on F1 ecosystems, under influence of edge, was so abundant that absolute protein quantities per unit area were considerably higher in the open and first 50 feet of edge than on F4 ecosystems. However, under mature stand conditions where browse production was more nearly the same, protein yields were greater on F4 ecosystems.

Table 4. Estimated crude protein (kilograms per hectare per year) contained in *Vaccinium ovalifolium* browse in December on 2 ecosystems in southeast Alaska

Ecosystem	Distance into residual stand in feet				
	Open	0	50	100	200
F1	37.8	11.7	7.8	5.2	3.0
F4[1/]	23.3	9.7	7.7	6.4	5.1

1/ Based on curve F4(b) in fig. 1.

It follows, therefore, that if the large quantities of *Vaccinium* at the edges of residual stands on F1 ecosystems remain available during the critical winter months (are not buried by snow accumulation), carrying capacities of these ecosystems may lend themselves to manipulation through judiciously controlled clearcutting procedures. Maintenance of the stand character beyond ± 20 years is dependent upon subsequent silvicultural treatments (that is, thinning, selective cutting, fertilizing). Conversely, the high quality habitat (food plus cover) found on F4 ecosystems apparently cannot be realistically improved through stand manipulation. This is determined in table 5 which was constructed based on data from this study. This table assesses the impact of clearcut size and shape on available *Vaccinium* biomass of these ecosystems, assuming winter snowpack prohibits use of the actual clearcut area, but not the edge areas.

Table 5. Estimated annual production and removal of protein (from *Vaccinium* spp.) in kilograms per hectare per year on F1 and F4 ecosystems as influenced by size and shape of clearcut unit

Area (hectares)	Shape (a)	Produced (b) F1	Produced (b) F4	Kilograms Protein Removed (c) F1	Kilograms Protein Removed (c) F4	Gain or Loss F1	Gain or Loss F4
2.0	Square	10.4	6.3	5.6	9.0	4.5	-2.7
2.0	Rectangle	11.2	7.2	5.6	9.0	5.4	-1.8
4.0	Square	14.8	9.0	11.2	18.0	3.2	-9.0
4.0	Rectangle	16.6	10.4	11.2	18.0	5.4	-7.6
8.1	Square	20.7	12.6	22.5	36.4	-1.8	-23.8
8.1	Rectangle	22.5	14.0	22.5	36.4	0	-22.5
20.2	Square	32.4	20.2	56.7	90.9	-24.3	-70.6
20.2	Rectangle	36.0	22.0	56.7	90.9	-20.7	-68.8
40.5	Square	45.9	28.4	113.4	182.2	-67.5	-153.9
40.5	Rectangle	50.4	31.5	113.4	182.2	-63.0	-150.8

(a) Rectangle dimensions were obtained using a ratio for sides of 2.4:1.0.
(b) Average values for protein were obtained by adding observed values at distances 0, 50, and 100 feet into the stand and dividing by 3. The values listed above represent effect of edge, based on curves F1 and F4(b), fig. 1.
(c) Values of protein yield observed at 200 feet into the stand were used to determine quantities that would be removed if a mature stand were cut.

By knowing (a) size of the clearcut unit, (b) soil ecosystem(s) involved and (c) perimeter of the unit, the theoretical impact (gain or loss of protein) of any harvest unit can be calculated. Based on the data from this study, the crude protein produced by edge around artificial openings can be calculated by the following:

F1 soils: Protein produced (kilograms) = 0.0180 x unit perimeter in meters.

F4 soils: Protein produced (kilograms) = 0.0113 x unit perimeter in meters.

Since the clearcut unit removed a portion of existing winter habitat, an allowance must be made. This loss can be calculated by the following:

F1 soils: Kilograms protein removed = 2.8 x unit size in hectares.

F4 soils: Kilograms protein removed = 4.5 x unit size in hectares.

The difference between protein removed and protein gained represents the change in *Vaccinium* biomass.

Summary and Application

The data presented in this paper indicate that the following conditions exist at least in the central portions of southeast Alaska:

1. The productivity of browse species (particularly *Vaccinium* spp.) responds positively to increased light in residual stands adjacent to artificial openings.

2. Growth response to increased light is much greater on F1 and closely allied F2 ecosystems than on F4 ecosystems.

3. The average percent crude protein content of the principal browse species, *Vaccinium ovalifolium*, is consistently greater on F4 ecosystems than on F1.

4. If 5 percent crude protein content is to be considered a minimum level to maintain black-tailed deer that have access to abundant, high quality summer browse, then adequate nutrition levels exist on F1 and F4 ecosystems under all stand conditions tested.

Timber harvest and deer management can, and should, be compatible forest management objectives. In southeast Alaska, where winter conditions can be very harsh, it is believed that cutting in lowland winter concentration areas may actually result in a net decrease of substantially nutritive deer browse [Klein, in Meehan, 1974]. Pending further investigations, primarily directed at assessing the energy requirements of black-tailed deer in southeast Alaska under stress conditions, the availability of forage located in edge situations (that is, obliteration of edge by snowpack) and the relative importance of protein content as opposed to cover and other food value indices (fat content, digestibility, etc.), the following suggestions are made with regard to harvest of climax stands in southeast Alaska where deer populations are of concern:

A. Timber harvest should be concentrated at elevations above key deer winter concentration areas. This will preserve existing critical winter forage and greatly increase late fall and early summer forage. Only where sufficiently large areas of F1 ecosystems are present to allow habitat improvement, should stand manipulation be considered. As Meehan [1974] stated, management should aim at forage availability somewhere between that of a mild and severe winter.

B. If timber is to be removed within 1 mile (1.6 kilometers) of the beach line or below 500 feet (150 meters) elevation in key deer wintering areas, F4 ecosystems or F14 and F24 complexes should generally be given preference as optimal deer habitat. Accordingly, harvest should be concentrated on F1 ecosystems, utilizing small (preferably less than 8 hectares) irregularly-shaped openings with multiple entry to maintain edge until other silvicultural treatments can be tested to maintain adequate browse conditions beneath second-growth stands.

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Admiralty Island Deer Study and the Juneau Unit Timber Sale

by

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Introduction

U.S. Plywood-Champion Papers, Inc. was awarded the Juneau Unit Timber Sale by the U.S. Forest Service in February, 1968. The contract called for the construction of a mill complex which could process the 8.7 billion board feet of timber that would be harvested by the company over the following 50 years. Almost immediately, the company organized a team of 7 university ecologists to provide advice on how to minimize environmental damage which might arise from the Company's activities.

These advisors soon concluded that they required more detailed ecological information than was currently available for the sale area if they were to be effective. The company obliged by funding several field projects including surveys of marine, freshwater and terrestrial ecosystems. I was hired by the advisory team in June, 1970 to work and interact with company foresters who were beginning to formulate detailed cutting plans for the initial operating areas. The object was for me to provide immediate, on-the-ground advice on the short- and long-term consequences of logging practices on wildlife, and to act as an observer for the advisory team.

My program did not proceed as planned, however. By the time I arrived in Juneau the Company had halted all field operations indefinitely--the Sierra Club, which questioned the legality of the Juneau Unit Sale, had filed a suit against the Forest Service. Consequently, it was determined that I should reorient my program to provide a comprehensive report to the advisory team on the implications of the timber sale for wildlife. Recommendations for minimizing adverse impacts and for enhancing important wildlife resources were to be included [Leopold and Barrett, 1972].

Lacking the expected logistical support by the Company, my travels were limited to trips provided by a variety of groups, particularly the U.S. Forest Service, the Alaska Department of Fish and Game, and the U.S. Fish and Wildlife Service. I determined that, given these constraints, I should make 1) a brief aerial reconnaissance of the entire sale area, 2) an extensive foot survey of all initial operating areas, and 3) an intensive survey of all terrestrial vertebrates in a single drainage within the initial operating area. Upon completion of field work in July, 1971 a report was

prepared and eventually submitted to U.S. Plywood-Champion Papers [Leopold and Barrett, 1972]. The Company subsequently asked the Forest Service to break the timber sale contract. This concluded the third attempt by the Forest Service to offer a large-scale, long-term timber sale in the northern third of southeastern Alaska.

This paper focuses on the intensive survey of a 4,726-acre drainage in South Arm, Hood Bay, Admiralty Island, with an emphasis on relationships between timber and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*). Although the Sitka deer is an important member of the wildlife community, it was only 1 of many species surveyed in the drainage. The project may best be described as a preliminary trial of a method for surveying terrestrial vertebrates rather than a detailed analysis of Sitka deer ecology.

Literature Review

After reviewing the literature on Sitka deer ecology available in 1970 [Cowan, 1956; Klein and Olson, 1960; Klein, 1965; Merriam, 1970; Perensovich, 1970], as well as the considerable literature on deer in North America [see, for example, Edwards, 1956; Taylor, 1956; Laramie and Dole, 1957; Brown, 1961; Taber, 1961; Pengelly, 1963; Dasmann, 1969; Loveless, 1964; Verme, 1965; McCaffery and Creed, 1969; McGinnes, 1969; Gilbert and others, 1970; Telfer, 1970] several points emerged. Foremost, the timber sale area lies at the northern edge of the mule deer/black-tailed deer's range. The environmental factor most likely limiting the northern distribution of deer is snow depth. Several studies have indicated the importance of winter cover, primarily in the form of dense evergreen timber, for minimizing heat loss and, more important, for moderating snow coverage of deer forage [Ozoga, 1968; Telfer, 1970; Moen, 1973]. A second point was that predators, particularly the wolf, could be a significant influence on deer populations [Merriam, 1964]. Thirdly, variation of snowfall in time and space was an important disruptive factor, periodically triggering major die offs, especially in areas lacking predators [Klein and Olson, 1960].

Based on these points, I hypothesized that on Admiralty Island, where there were no significant predators of deer, the availability of browse (*Vaccinium* spp.) during the winter was the critical factor influencing deer distribution and abundance. Browse availability was, presumably, influenced primarily by 1) soils, 2) light, 3) snow depth, and 4) past utilization. Timber stand density, particularly canopy cover, influences both light and snow levels, and logging certainly modifies the timber stand. These relationships are not necessarily simple linear ones however; and whether or not logging would favor deer in the sale area was not immediately clear.

Field Work

Winter track surveys--When I arrived in Juneau I was repeatedly told that during deep snow conditions deer were forced down to the beaches. As the winter of 1970-71 was relatively severe, I attempted to document this pattern by counting the number of deer tracks per eighth-mile transect per day since the last snowfall (maximum 8 days). Personnel from the U.S. Forest Service and the Alaska Department of Fish and Game assisted me in checking over 30 miles of transects between February 19 and April 5, 1971. All transects were walked by two persons about 100 yards apart, each making separate tallies of tracks.

Two results are worth mentioning. First, the correlation of paired transects was statistically insignificant; by shifting only 100 yards one could obtain a very different picture of deer distribution and abundance. This suggested that deer in a climax hemlock-spruce forest may be responding to a rather fine-grain habitat mosaic. Second, although it is true much deer sign was close to saltwater, I found deer using areas with snow depths of less than 24 inches as far as 3 miles inland. This suggests that snow depth is the critical factor, although it is strongly correlated with elevation and distance to saltwater.

While I was working in the South Arm of Hood Bay in midwinter, I took the opportunity to follow the fresh tracks of several deer along their daily travel routes. A crude mapping of these routes indicated that with snow depths of 12-24 inches deer were moving within a daily home range area of less than 40 acres. It would be important to consider at least this degree of resolution when assessing the consequences of logging plans on deer winter range.

Spring pellet group survey--By May, 1971 I had concluded that track surveys could provide a very crude assessment of deer distribution and abundance for a short period when snow conditions were appropriate. However, the data returned did not seem worth the considerable cost expended to obtain it. I decided, consequently, to systematically survey one entire drainage by counting accumulated deer pellet groups (and other animal sign) after snow melt but prior to much plant growth (May 28 to June 15, 1971). Thirty man-days, involving two persons, were expended to sample 0.33 percent of that portion of the South Arm, Hood Bay creek drainage below 1,500 feet elevation. This corresponds roughly to the timbered portion of the drainage, and, to the transitional and winter deer range in the watershed.

Counts of accumulated deer pellet groups were made on 112 belt transects (5 x 660 feet = 0.0765 acres) and 124 circular plots (11.7 feet radius = 0.01 acres). Plots and transects were laid out systematically along east-west section lines and at 1/4-mile intervals inbetween. A circular plot was located every 1/8-mile by pacing along the transect (fig. 1). Several variables were recorded for each plot location (table 1). The objective was to substantiate the relative value of several environmental factors, including timber stand density and *Vaccinium* density, for predicting deer use. A preliminary analysis consisting of a series of simple, single-factor regressions was presented by Leopold and Barrett [1972].

Inadequacies of the data--One major flaw and several lesser problems exist in the data collected. I was not able to accurately assess browse availability as affected by snow cover because the snow was gone by May. However, to accurately count pellet groups, I had to wait for the snow to melt. The only solution to this dilemma would have been to make multiple visits to permanently marked plots. There was not sufficient time for this degree of effort during the study. Thus, the hypothetically most important variable was not measured directly.

I had no information on the length of time over which pellet groups persist and accumulate, nor on differential weathering between sites. Papers by Bunnell and Fisch, respectively, in these proceedings, discuss this subject. They suggest that the great majority of the pellet groups were deposited during the preceding winter.

The 0.01-acre sample area was too small to provide pellet group counts approximating a normal distribution. It would be preferable to use clusters of plots at each sample site such as those used by Willms [1971:36]. Based on the frequency distribution of my data, I would recommend a cluster of 20-40 circular 10-square-meter plots (radius 178 centimeters).

Figure 1--Geographical location of deer winter range sample plots in the South Arm, Hood Bay creek drainage, and the number of accumulated deer pellet groups at each plot. [*Plots with over eight pellet groups (top 10 percent) are circled. Dashed lines outling the summer range.*]

Table 1. Habitat variables measured on 124 sample plots in the South Arm, Hood Bay creek drainage

Variable	Measurement	
Plant Species Present [Hulten, 1968]	Trees on 0.1 acre plot	Herbs on 0.001 acre plot
	Hemlock	*Cornus*
	Spruce	*Rubus*
	Cedar	*Coptis*
	Alder	*Lysichiton*
	Shrubs on 0.01 acre plot	*Tiarella*
	Vaccinium	*Streptopus*
	Menziesia	*Moneses*
	Oplopanax	Ferns
	Ribes	Liverworts
Proximity to Saltwater	Map distance in 0.1 miles	
Elevation	Feet above sea level, pocket altimeter	
Slope	Percent, pocket clinometer	
Radiation Index [Frank and Lee, 1966]	Calculated from latitude, aspect and slope	
Spruce Density	Trees > 6 inches DBH/0.1 acres	
Hemlock Density	Trees > 6 inches DBH/0.1 acres	
Vaccinium Density	Stems/0.01 acres	
Menziesia Density	Stems/0.01 acres	
Oplopanax	Stems/0.01 acres	
Spruce Basal Area	Square feet/acre, 40 BAF prism	
Hemlock Basal Area	Square feet/acre, 40 BAF prism	
Total Basal Area	Square feet/acre, 40 BAF prism	
Gross Timber Volume	MBF/acre Scribner Scale	
Vaccinium Height	Inches, tape measure	
Pellet Group Density	Number/0.01 acres	

Finally, some of the habitat variables were measured on plots of variable area. It would be preferable to sample equal areas for all variables or, at least, subsample a standard area with an appropriate subsampling scheme. I suggest that a standard sample area of 50 x 50 meters (164 x 164 feet) or 0.25 hectares (0.1 acres)--1.5 percent of a 16-hectare (40-acre) deer home range--would be appropriate for the analysis of habitat preference. Such plots should be located on the Universal Transverse Mercator Grid [Strahler, 1960:59].

Estimating deer density--Based on a mean of 23 accumulated pellet groups for 112 belt transects, I calculated a range of possible deer densities for varying defecation rates and pellet accumulation periods (table 2). Based on a general impression of the degree of weathering of pellet groups counted, I guessed that over 1/2 of the accumulation was deposited during the past winter season. Assuming a defecation rate of 13 pellet groups per day [Neff, 1968] and an accumulation period of 240 days (allocated over 2-3 winters) the transect data provide an estimate of 62 deer per square mile of winter range with 95 percent confidence bounds of ± 15 percent, or 53-75 deer per square mile. A similar analysis using the 124 circular plots provides roughly similar results (table 3); but in this case, the confidence bounds are questionable due to the skewed distribution of the pellet group data.

Table 2. Density of deer per square mile of South Arm, Hood Bay creek winter range based on a mean of 23 accumulated pellet groups per 5- x 660-foot belt transect and varying defecation rates and accumulation periods.

Accumulation Period, Days	Defecation Rate, Pellet Groups Per Day								
	10	11	12	13	14	15	16	17	18
120	162	148	135	125	116	108	102	96	90
150	130	118	108	100	93	87	81	76	72
180	108	98	90	83	77	72	68	64	60
210	93	84	77	71	66	62	58	55	52
240	81	74	68	62	58	54	57	48	45
300	65	59	54	50	46	43	41	38	36
360	54	49	45	42	39	36	34	32	30
420	46	42	39	36	33	31	29	27	26
480	41	37	34	31	29	27	25	24	23
540	36	33	30	28	26	24	23	21	20
630	31	29	26	24	22	21	19	18	17
720	27	25	23	21	19	18	17	16	15

Table 3. Density estimates for Sitka deer on climax spruce-hemlock winter range below 1,500 feet elevation in South Arm, Hood Bay creek drainage. Estimates assume a defecation rate of 13 pellet groups per day and an accumulation period of 240 days.

	0.01-acre circular plots	0.0765-acre belt transects
Sample Size	124	112
Mean Pellet Groups per Plot/Transect	2.685	23.00
Standard Error	0.348	1.758
Deer Density per square mile	55	62
95% Confidence Range	41-69 (±25%)	53-73 (±15%)
Deer Population on 2,947-acre Range	189-318	244-332

If the sample plots are segregated by elevation the data indicate a preference by deer for winter range between 200 and 700 feet above sea level (table 4). The total deer populations indicated in table 4 are probably more accurate than those in table 3 because it was impossible to reach all sample plots allocated to the 700-1500-foot range. Stratification adjusts the estimates for this bias.

Table 4. Deer distribution in winter stratified by elevation for the South Arm, Hood Bay creek drainage. Estimates are based on pellet group data. Assumptions include a defecation rate of 13 pellet groups per day and pellet accumulation period of 240 days.

Elevation, feet	Acres	Square miles	Percent	Deer population based on: 0.1-acre plots	0.0765-acre transects	Preference index[1/] from: plots	transects
0-200	918	1.43	19.4	56	82	-.07	+.02
201-700	956	1.49	20.2	133	134	+.33	+.24
701-1,500	1,074	1.68	22.7	20	37	-.53	-.43
Total winter range	2,947	4.61	62.3	209	253		
Total drainage	4,726	7.39					

1/ Ivlev's preference index [Petrides, 1975]

Population estimates of 209 to 253 deer convert to densities of 45 to 55 deer per square mile of climax hemlock-spruce forest. Even 1/2 of this density is certainly higher than is generally credited to climax conifer forests [Brown, 1961; Willms, 1971]. The South Arm, Hood Bay creek drainage may be an unusual case, but these results suggest that truly uneven-aged climax forests may provide for a higher density of deer than has generally been realized.

Analyzing habitat preference--Hood Bay deer apparently prefer to winter at elevations between 200 and 700 feet. Since essentially the entire winter range in this drainage would be classified as "Climax Forest" by Taylor [1932] or "Coastal Forest" by Palmer [1942] or "Hemlock - Spruce Forest" by Hutchison [1967], I attempted a more refined classification of the 124 sample plots on the basis of presence of plant species. I also classified the plots by soil type as mapped by Billings and Bishop [1971].

Using only those plant species with a total frequency of occurrence over 5 percent (17 species), I carried out a numerical classification of the 124 sample plots. This was done using programs MULTBET, GROUPER, GOWER, GOWECOR and TWOWAY on the Commonwealth Scientific and Industrial Research Organization's CYBER 7600 computer in Canberra, Australia. This is an agglomerative (polythetic), hierarchical classification using the Simple Matching Coefficient for a resemblance function [Williams, 1971]. Classification was limited to 6 groups (vegetative types) (fig. 2).

Vegetation types 1 through 4 differed primarily in proportions of plant components and differed relatively little in terms of the other variables recorded (table 1). Type 5 was relatively distinct, occurring on moist sites supporting a large volume of spruce and dense stands of devilsclub. Type 6 was a miscellaneous group composed of plots falling in timber approaching muskeg sites or plots at high elevations in or adjacent to avalanche areas.

Deer showed some preference for vegetation types 3, 4 and 2 in that order (table 5). An analysis of pellet group distributions for each type indicated that at the scale sampled, deer are distributed contagiously (high variance-mean ratio [Duncan, 1972]) in all types, but the pellet group frequencies conform best to the negative binomial distribution in all types but 5 and 6, which conform best to the binomial poisson distributions, respectively (table 5).

By locating the sample plots on the soils map produced for the Hood Bay region by Billings and Bishop [1971] I was able to allocate each plot to a soil mapping unit. Pellet groups were found on some plots in all 13 soil mapping units in the drainage. The pellet group data and the precision of the soil type map are inadequate for a detailed analysis of a deer preference for soil types. However, it appears that deer sign is more abundant on the following soil mapping units:

1) F24, Tolstoi-Woewodski complex, sloping,
2) B, Shakan very stony loam,
3) F12, Tolstoi-Kupreanof complex, sloping,
4) F1, Kupreanof very gravelly loam, steep, and
5) F1, Kupreanof very gravelly loam, sloping.

Table 6 illustrates a relatively unsuccessful attempt to relate the 6 vegetation types I constructed to the 13 soil mapping units in the Hood Bay creek drainage. The lack of clear relationships is probably due to mapping soil complexes rather than individual Series, and to the crude nature of my vegetation classification. I suspect the relationships would become much clearer with more data from additional sites, including ground determinations of specific soil Series. I was not equipped to do this in my survey.

Figure 2. The pattern of plant species present on 124 sample plots (0.001 to 0.1 ac) distributed systematically over the South Hood Bay Creek drainage. Horizontal axes indicate number of plots in each type; dark blocks indicate the presence of plant specis on each plot. The plots were divided into 6 vegetative types and the plant species into 5 groups by a numerical taxonomic procedure. See text for details.

Table 5. Deer preference for, and disperson pattern in, 6 vegetation types defined by the presence of 17 plant species. Availability of each type was estimated by the frequency of each type in a systematic sample of the South Arm, Hood Bay creek winter range. Utilization was estimated by the accumulation of pellet groups in each type.

Item	Vegetation Type					
	1	2	3	4	5	6
Sample plots	28	26	28	19	14	9
Availability	.226	.210	.226	.153	.113	.072
Utilization	.217	.223	.310	.187	.048	.015
Ivlev's preference index [Petrides, 1975]	-.02	+.03	+.16	+.10	-.40	-.66
Mean pellet groups per plot	2.571	2.885	3.679	3.263	1.143	0.556
Variance	18.62	12.27	26.37	10.54	1.516	0.528
Disperson index [Duncan, 1972]	+.60	+.49	+.52	+.41	+.61	+.05
Negative binomial k [Bliss, 1953]	0.367	0.742	-.948	0.948		
Deer density per square mile*	53	59	75	67	23	11

*Estimate assumes a defecation rate of 13 pellet groups per day and a 240-day accumulation period (that is, 20.5 deer per square mile for each pellet group per 0.01-acre plot).

Table 6. Correspondence of USFS soil type classification for southeast Alaska and 6 vegetation types defined by presence of 17 plant species. Correspondence is indicated by the percentage of plots within each vegetation type for each soil type. Deer use is quantified by the mean number of accumulated pellet groups per 0.01-acre plot.

Soil Types	Vegetation Types 1	2	3	4	5	6	Deer Use (Range)
F1	29	14	29	14	14	0	3.0 (0-7)
F1	25	0	33	25	17	0	3.2 (0-11)
F1X	12	12	16	16	36	8	2.6 (0-10)
F2R	38	23	8	15	8	8	1.1 (0-5)
F4R	50	0	50	0	0	0	0.5 (0-1)
F5	0	67	0	33	0	0	1.7 (0-3)
F6	100	0	0	0	0	0	0.1 (0-1)
F12	30	20	30	17	0	0	3.8 (0-21)
F14	0	33	50	17	0	0	2.3 (0-10)
F24	25	75	0	0	0	0	5.0 (0-13)
F24	0	37	13	13	0	37	0.5 (0-2)
Mf5	13	26	25	13	0	13	2.0 (0-6)
B	50	0	0	0	0	50	4.3 (0-17)
Deer Use (Range)	2.6 (0-17)	2.9 (0-12)	3.7 (0-21)	3.3 (0-11)	1.1 (0-3)	0.6 (0-2)	2.7 (0-21)

Correlating deer use with habitat variables--I have shown that deer prefer certain elevations and soil-vegetation types. However, since it was impossible to measure directly the habitat variable which I hypothesized was the critical one influencing this selectivity, that is, *Vaccinium* availability, I am limited to assessing the degree of correlation between those habitat characteristics I could measure (table 1) and deer sign density. Although inadequate to explain patterns of deer habitat preference, some of these variables are easily measured and may be of value in mapping critical deer winter ranges.

I attempted to use multiple regression analysis. This work was done with various programs on several computers. Numerous models with various combinations of independent variables and many different transformations (including a ln(x + 1) transformation of the dependent variable to normalize its distribution and homogenize residual variation) provided me with the following inconclusive results. Simple correlation coefficients were highest between deer use and 1) hemlock basal area (r = .281) and 2) *Vaccinium* density (r = .183). *Vaccinium* density or *Vaccinium* volume (density x height) and hemlock volume or hemlock basal area were always significant main effects. However, they were always confounded; that is, there was always a significant browse x timber interaction. Thus, it was impossible to determine which factor was the most critical [Gilbert, 1973]. No other habitat variables were significant once browse and timber and their interaction were accounted for except for elevation and distance to saltwater, which were also confounded with each other.

In a case such as this, where rigorous statistical inference is impossible because the data do not meet the assumptions of the statistical model, one can resort to less rigorous models to obtain novel views of the data set in hopes of visualizing new hypotheses. These may subsequently be tested with appropriate experiments. The availability of advanced multivariate analysis programs (for example, see Goldstein and Grigal [1972], Gauch and Dripps [1973], Orloci [1975], Nie and others [1975], Finn [1977]) and large computers now make it feasible to contemplate analyzing large quantities of multivariate data, even if the sole purpose is to generate hypotheses rather than prove cause and effect relationships.

I suggest that these developments should be utilized by field biologists making routine surveys. It is not much more time consuming, once appropriate data forms and standardized field procedures are worked out, to gather multiple observations from a series of appropriately-located sample plots than it is to make a ground reconnaissance of an area. Simply getting to the site is generally the most costly operation. Over the years such multivariate data can develop into a considerable resource useful for constructing testable hypotheses for researchers if not for making sound predictions directly. Such a data bank would be especially valuable if data on other animals were included in addition to deer.

I will illustrate the use of discriminant function analysis, just one type of multivariate analysis, to look for deer-habitat relationships. Another multivariate strategy, not yet used with this data, is a combination of principal component analysis and multiple regression analysis. This was used by Hirst [1975] to assess ungulate-habitat relationships in South Africa. My analyses were made with the SPSS programs [Nie and others, 1975] on the CDC 6400 computer at the University of California, Berkeley.

One purpose of a discriminant function is to provide a means of objectively segregating samples into 2 or more predetermined categories, based on values for 2 or more numerical variables recorded for each sample. The analysis provides a set of standardized discriminant function coefficients (1 for each numerical variable) for each discriminant function. If there are n predetermined categories then there can be no more than n - 1 functions [Nie and others, 1975]. Of interest here is that the absolute magnitude of the standardized discriminant function coefficients indicate the relative importance of each (habitat) variable in discriminating between the predetermined categories. In this case the categories are: 1) no deer use, 2) light deer use, and 3) heavy deer use. The results of such an analysis can be visualized with a plot of individual sample scores on axes defined by the first two discriminant functions. The distance between group centroids relative to the within-group dispersion of sample scores illustrates the discriminative power of the functions.

I made many analyses using different combinations of habitat variables transformed in various ways. The results of 1 of these are presented in table 7 and fig. 3. Only

Table 7. Standardized discriminant function coefficients for 12 Sitka deer winter range variables used to distinguish between degrees of deer use as indicated by accumulated pellet groups.

Habitat Variable	Transformation	Standardized Coefficients Function 1	Function 2*
Vaccinium density	x + 1	-1.34468	-0.34727
Spruce basal area	x + 1	-0.79786	+1.72912
Hemlock basal area	x + 1	-0.57975	+0.09913
Vaccinium height		+0.57477	+0.16751
Oplopanax density	ln (x + 1)	-0.54853	-0.20670
Timber basal area	x + 1	+0.54622	-1.40811
Menziesia density	ln (x + 1)	-0.46086	-0.45532
Distance to saltwater		+0.41600	-0.42646
Spruce density	ln (x + 1)	+0.32824	-0.59348
Hemlock density		-0.28467	+0.18998
Shrub density	x + 1	+0.27598	+0.40002
Percent slope	Arcsine x	+0.18359	+0.16976

*The second function provides no significant additional discrimination power to the first function.

the first discriminant function of the 2 possible with 3 categories of deer use provided a significant degree of discrimination (84 percent of the total discrimination possible with the 12 habitat variables included). Only 57 percent of the samples could be correctly classified as to degree of deer use.

Of greater interest are the standardized discriminant function coefficients for the habitat variables (table 7). Only absolute values are important, the sign of the relationship to deer use must be determined by inspecting the original data. Thus, in this example, the habitat variables most useful for distinguishing high levels of deer use were: 1) high *Vaccinium* density, 2) low spruce basal area, and 3) high hemlock basal area. Note that high *Vaccinium* density without low spruce and high hemlock basal area is insufficient to indicate good deer habitat.

I have attempted 1 additional analytical strategy which produced interesting results. I carried out a discriminant function analysis with vegetation types 1 through 5 as predetermined categories, and all the habitat variables other than plant species presence (used to develop the vegetation types) as independent variables. Four discriminant functions were calculated and these were capable of classifying 62 percent of 115 sample plots to their correct vegetation type using 14 habitat variables.

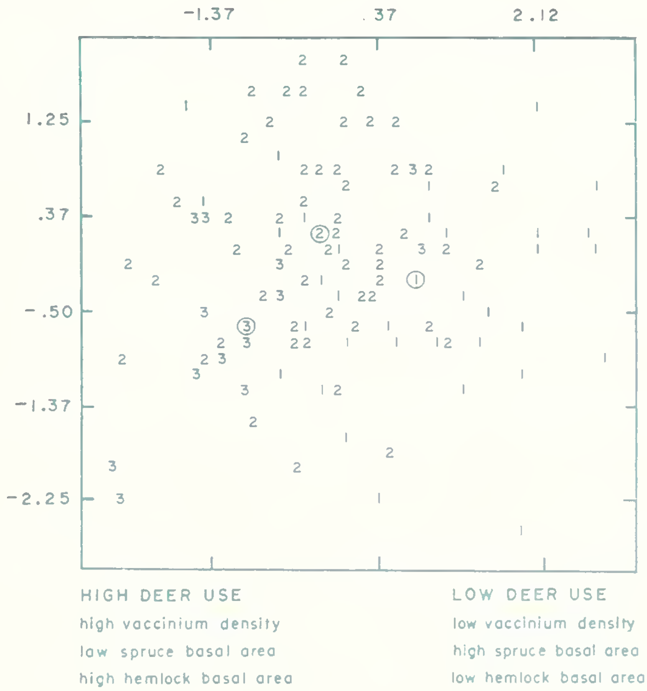

Figure 3--Plot of discriminant score 1 (horizontal) versus score 2 (vertical) for 115 sample plots (vegetation types 1 through 5) grouped by degree of deer use (1 = centroid for zero, 2 = centroid for 1 - 7, and 3 = centroid for 8 - 21 pellet groups per 0.01 ac plot).

Then I used multiple regression analysis to determine if there was any relation between deer use (pellet group accumulation) and the discriminant scores (1 through 4) calculated for each plot. Only function 3 was significantly related to deer use ($r = .291$). I then reviewed the standardized discriminant function coefficients for function 3 to determine which habitat variables were most important in characterizing that function. Function 3 represents a gradient of high *Vaccinium* density to high devilsclub (*Oplopanax*) density (table 8). Checking back to the original data one can determine that high deer use is positively correlated with *Vaccinium* density and negatively correlated with devilsclub density. Thus, in all analytical strategies attempted, although none are conclusive, all indicate that *Vaccinium* abundance is correlated with high deer use. In some analyses hemlock cover, elevation or distance to saltwater were also important. All these factors are confounded, with many significant interactions, and, all of them are related in a complex way to the availability of preferred browse where there is significant snow cover during the winter.

Table 8. Standardized discriminant function coefficients for 14 habitat variables used to distinguish between 5 vegetation types classified by the presence of 17 plant species in the South Arm, Hood Bay creek drainage. Note that deer use was significantly correlated only with function 3 although it accounted for only 8 percent of the discriminative power provided by all 4 functions calculated.

Habitat Variable	Transformation	Standardized Coefficient Function 3
Vaccinium density	x + 1	+2.06938
Oplopanax density	ln (x + 1)	+0.97010
Shrub density	x + 1	-0.63789
Timber basal area	x + 1	-0.63491
Vaccinium height		-0.59410
Spruce density	ln (x + 1)	+0.48655
Hemlock basal area	x + 1	+0.47675
Spruce basal area	x + 1	+0.39528
Distance to saltwater		-0.38643
Elevation	ln (x + 1)	+0.26251
Menziesia density	ln (x + 1)	-0.24850
Hemlock density		-0.13321
Gross timber volume	x	+0.08302
Percent slope	Arcsine x	-0.04293

Discussion

My purpose here is not to provide conclusive information on Sitka deer-habitat relationships. It was impossible at the time to directly measure the relationship between deer use and *availability* of preferred browse, which I hypothesized is the most critical factor determining the distribution and abundance of deer on their winter range. Rather, my goal has been to suggest that field biologists now have the opportunity, due to the availability of large computers and multivariate analytical methods, to quantify their observations made during field reconnaissances. Previously, much data was not collected because it was unlikely that anyone could make use of it. I suggest field surveys should now involve more quantification of observations. Moreover, these observations should be collected in a standardized manner, and with some thought to appropriate sampling systems. Such data accumulated over time can be expected to provide useful hypotheses for experimental research. In addition, such efforts would be especially valuable if data on the abundance of animals other than deer were also collected simultaneously. Some species may be influenced by competitors and predators as much as by habitat variables. For example, deer distribution on the southeastern Alaska mainland may be strongly influenced by wolf distribution.

The data and the analyses I have presented all lend support to, but do not confirm, my hypothesis that deer distribution during the winter is determined primarily by the availability of preferred browse, which is in turn influenced strongly by snow depth. Climax conifer forests are generally considered poor habitat for deer. My data suggest that this generalization needs some qualification. The old-growth, uneven-aged stands of hemlock and spruce in the South Arm, Hood Bay creek drainage are apparently supporting a surprisingly high density of Sitka deer through the winter months. These deer do not concentrate only along the beaches, but rather prefer elevations of 200-700 feet, and stands of moderately high timber volume, particularly hemlock stands with understories of *Vaccinium*. The continuing cycle of regeneration and death of individual trees in these climax stands provides a fine-grain mosaic of available food and cover which may be optimum for the maintenance of Sitka deer populations near the northern limit of their range.

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Wildlife-Forestry Planning in the Coastal Forests of Vancouver Island

by

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Introduction

Wildlife-forestry discussion in the province of British Columbia has traditionally centered around moose-spruce, elk and burning. There is little published material discussing the wildlife resource of the coastal forests or their dependence on coastal biogeoclimatic zones of British Columbia.

Several features of Vancouver Island (Region 1) make it unique in the ecological planning process. The timber resource per unit area is the most valuable in Canada. The forests of Vancouver Island produce about 20 percent of the timber volume in British Columbia and about 10 percent of that of Canada. The coastal Douglas-fir biogeoclimatic zone is undoubtedly the most productive zone in Canada when fibre, fish and wildlife are considered. The black-tailed deer harvest from the Island contributes 30-45 percent of the total deer harvest (all species) in British Columbia (table 1). Specifically, the Nimpkish River Valley provides about 12 percent of the total deer harvest in British Columbia from a land base which comprises only 0.2 percent of the total deer range. Productivity of the forest resource has expressed itself through total commitment of the forest land base. Tenure type is regulated for single-resource use and is so restrictive that wildlife management and planning are being curtailed. The economic and social value of the forest resource is extremely important to the people of British Columbia and the winter range requirements of black-tailed deer in the interior of the Island are so critical that direct conflicts are inevitable.

Table 1. Relationship of the area contributing to the deer harvest on Vancouver Island to that of the Province

	Vancouver Island	Nimpkish River
Time period	1964-1974	1972-1974
Black-tailed deer harvest	23,000	3,000
Percent of total deer range in British Columbia	4	.2
Percent of total deer harvest in British Columbia	30-45	11-12

Study Area

According to the landform classification [Holland, 1964], Vancouver Island, except for a narrow strip of lowland along the eastern and northern coasts, is included within the Vancouver Island Mountains of the Insular Mountains. The lowland areas, including the Nanaimo Lowland and the Nahwitti Lowland, are parts of the Coastal Trough and lie below 2,000 feet elevation, their boundary with the mountains being drawn along the line of the 2,000-foot contour. In fact, that portion of the Lowland area that can be effectively utilized by black-tailed deer, without snow as a major influence, lies below 1,000 feet elevation and often below 500 feet elevation.

Vancouver Island is largely composed of 3 biogeoclimatic zones: the coastal western hemlock, the coastal Douglas-fir, and the mountain hemlock zones [Krajina, 1965]. Recently, the coastal hemlock and Douglas-fir zones have been divided into wet and dry subzones. The coastal Douglas-fir zone comprises the low-lying areas of the east-central and southeast portions of Vancouver Island. The coastal western hemlock zone comprises the remainder, except where the mountain hemlock zone occurs at higher elevations. The ecology and survival of black-tailed deer is directly related to the annual snowfall of each zone. The Douglas-fir zone receives 14-42 inches on an annual basis; the coastal western hemlock zone receives 5-295 inches; and, the mountain hemlock zone receives 110-800 inches on an annual basis.

Tenure Distribution

Many of the problems surrounding forestry-wildlife interactions on Vancouver Island result from the amount and distribution of the various tenures. Within British Columbia approximately 95 percent of the provincial forest land is public land and is theoretically managed under a sustained-yield concept, incorporating integrated land use where possible. However, much of the remaining 5 percent, which is privately owned, is located on Vancouver Island and is managed almost strictly for timber harvest pruposes. Thus, almost 30 percent of Vancouver Island is privately owned (fig. 1).

Figure 1--A description of the Forest Tenure of Vancouver Island. For explanation of tenure types, see T.F.C.T.D. 1974

An additional 50-60 percent of the land base is managed under Tree Farm License (TFL) contract between the government and industry. Within the province, the greatest number of TFL holders occurs on Vancouver Island. In addition, the Forest Act, or forest resource policy, supports and directs management of the majority of the coastal forests for single-use extraction. However, a new Forest Act, the result of a Royal Commission and Forest Policy Advisory Committee recommendations, is presently under consideration by the Provincial Cabinet and is expected to be legislated this summer. This Act, with accompanying regulations, *may* reflect improvements in the integration of forest resource management.

The present situation has placed the Fish and Wildlife Branch in the position of allocating or doling out a rapidly diminishing resource, with no management control of the land base or habitat which sustains the resource. According to fig. 2, the District Forester of the British Columbia Forest Service has more control (6 points of a possible 10) over the black-tailed deer resource than does the Regional Wildlife Biologist (2 points of a possible 10).

Wildlife-Forestry Planning

An effective planning process which can provide for the long-term retention of critical black-tailed deer winter ranges must include:

A. a comprehensive description of the wildlife resource and its seasonal requirements;

B. the interaction between resource agencies with identification of conflicts and problems;

C. changes in the single-use policies originally developed for single-use management; and

D. boundaries within which integrated management can function (tenure; only briefly mentioned).

A. *Wildlife resource requirements*--Certain of the wildlife-forestry conflicts arise from an improper understanding of the habitat-deer relationships which exist throughout Vancouver Island and the winter habitat requirements of the central Island deer population. Early biological studies in Washington [Brown, 1961; Dasmann and Hines, 1959] and on southern Vancouver Island [Cowan, 1945] suggested that logging provides benefits (mainly food production) which, otherwise, were supposedly unavailable to deer populations in mature forests. Cowan [1945] provided figures which suggested that one deer per square mile inhabited the mature forests of southwest Vancouver Island, that 20 deer per square mile inhabited logged portions of southeast Vancouver Island, and, up to 30 deer per square mile inhabited logged areas further north in the Cowichan Valley. This preliminary information from Washington and British Columbia was used to formulate the lower curve in fig. 3 and produced the idea that logging provides tremendous benefits to black-tailed deer. This idea persisted for over 25 years in the minds of many biologists, most foresters (because they had little other information to rely on), the logging industry, and, the general public.

The lower curve (fig. 3) depicts a population which is low (1 to 5 deer per square mile) prior to logging (mature forest), increases dramatically during logging (30-100 deer per square mile), and which declines to original levels upon completion of the 20-year food producing successional stage [Gates, 1968] and regeneration of the

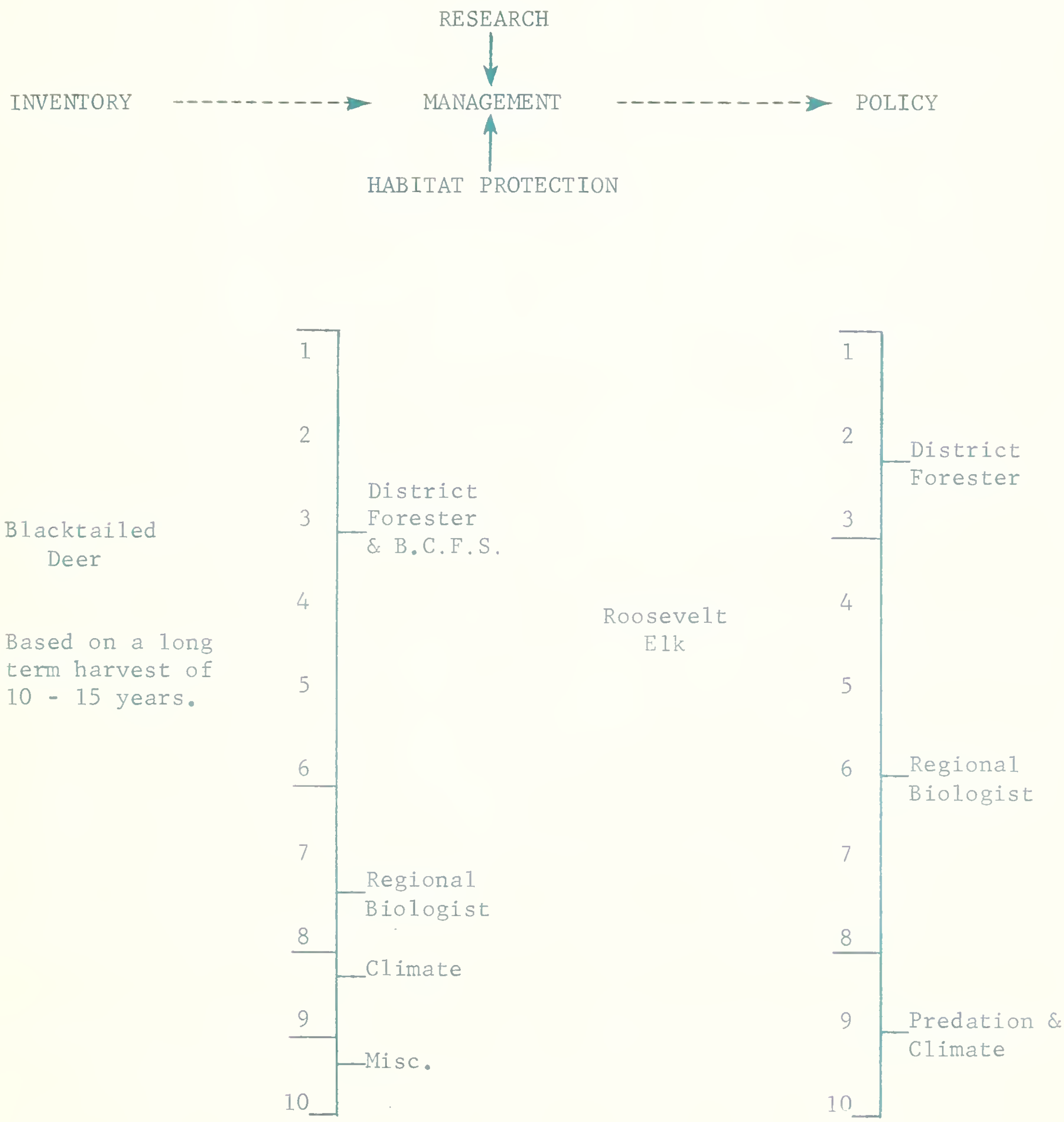

Figure 2--Management control of the wildlife resource of Vancouver Island

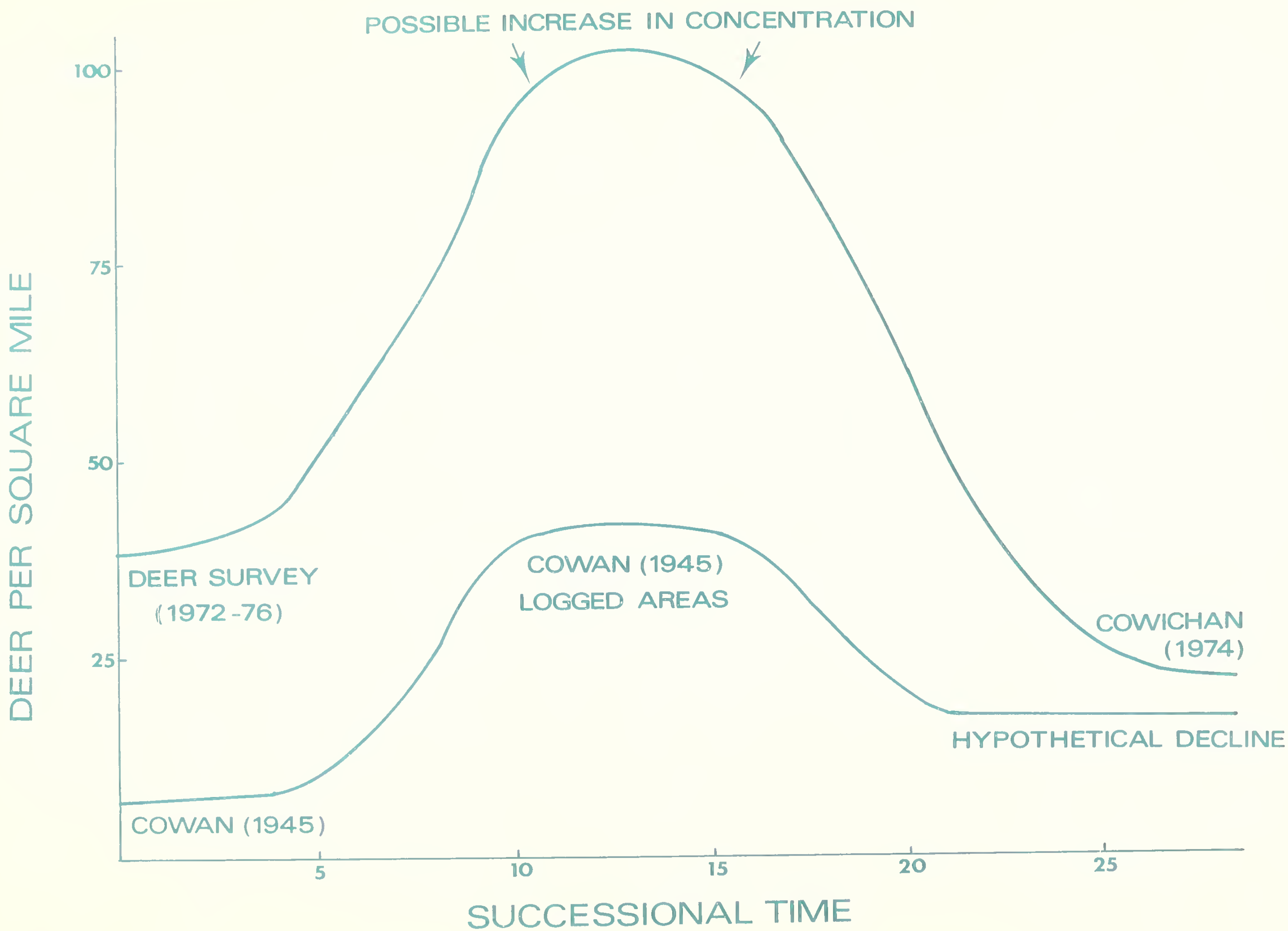

Figure 3--Estimation of population levels in mature forest and population changes due to timber harvest practices

second-growth forests. Traditional thinking of this type contributed little argument against the large clearcuts (5-15 square miles) which developed on Vancouver Island, nor for the retention of mature forests as deer winter range in areas of high snowfall.

Information gathered since 1972 indicates that deer densities in mature forests could range from 25-60 deer per square mile on a watershed basis (table 2) on the east coast and the central and northern portion of Vancouver Island. Similarly, specific winter ranges in unlogged watersheds have known densities [Smith and Davies, 1975] of 75-150 deer per square mile. By comparison, densities on selected south slope areas (winter ranges) in the Cowichan Valley [Hanna and Foucher, 1974] range from 5-10 deer per square mile in second-growth forests ranging from 20-75 years of age. Similarly, Davies [personal communication] found deer densities of 10-20 deer per square mile on select south slope areas in the Cowichan Valley, after 3 mild winters. This information, based on comparative pellet group transect methodology was used to construct the upper curve in fig. 3. It indicates that logging can produce a definite NET LOSS to black-tailed deer populations which could reach *80-90 percent* if the decline is measured between winter ranges in second-growth versus mature forests. It substantiates the statement [John W. Schoen, personal communication] that optimal black-tailed deer winter habitat in snowbelt areas may be a NON-RENEWABLE resource if timber harvest proceeds in its present form.

The myth that all logging increased deer populations was further supported by an increase in the visibility of many populations, forced to forage in slash and early second-growth regeneration and to winter in ever-decreasing blocks of mature timber winter range. It appears that deer populations declined in response to the period of logging in any particular watershed (fig. 4), but that density increased for a portion of that time, increasing visibility and harvest success.

It is quite likely that Cowan's [1945] figures of 30 deer per square mile underestimated the concentrated population due to logging. However, it would be dependent on stage of logging at the time and may reflect the state of population decline and change in density with time (fig. 4 showing eventual decline in density). It is possible and likely that deer populations in the mature Douglas-fir forests of the east coast of Vancouver Island reached 50-75 deer per square mile on a watershed basis and could have attained levels of 75-200 deer per square mile on specific mature timbered winter ranges for a short time, due to the population concentrating effects of logging. For example, while Cowan [1945] suggested deer densities of 20-30 deer per square mile in Management Unit I-2 (fig. 5) on southern Vancouver Island, the harvest density (deer harvested per square mile) in this area reached 9-10 deer per square mile (table 3). If the harvest density is 10 percent of the population, the population could have reached 100 deer per square mile.

Harvest statistics produced by the hunter sample and hunter checks support the deer-habitat relationships established to date. The harvest statistics information is currently collected, analyzed, and interpreted according to management unit boundaries as shown in fig. 5. In fact, since 1975 the information has been handled on a subunit or watershed basis. Approximately 225 subunits comprise the 13 management units. Accordingly, deer harvests in the heavily logged portion of southern Vancouver Island (table 3) (Management Units I-1 through I-8) have declined 50 percent overall (figs. 6 and 7) and up to 75 percent (table 4) in specific watersheds, during the period 1964-1974.

Currently, northern Vancouver Island (Management Units I-9 through I-13) is following (7-15 year lag) the trend of southern Vancouver Island (fig. 8). Deer harvests have increased on the northern part of the Island due to improved access, human population increase, and the availability of heretofore unexploited deer populations. The advent of extensive timber harvest operations produced declines in deer harvest in

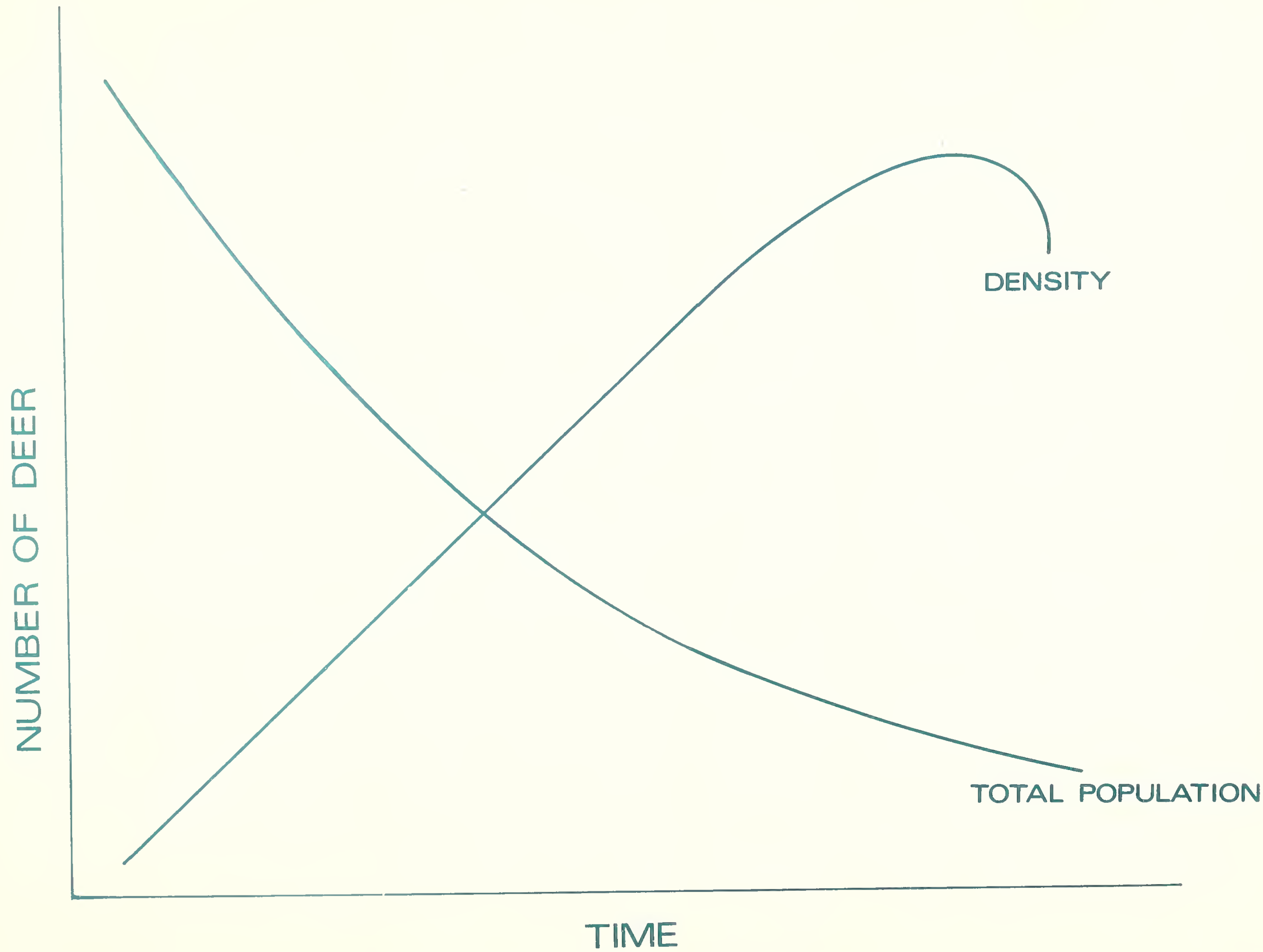

Figure 4--The possible change in total population and population density during timber harvest of a watershed

Figure 5--A description of the management unit boundaries and locations

Figure 6--The approximate deer harvest trend for southern Vancouver Island deer populations

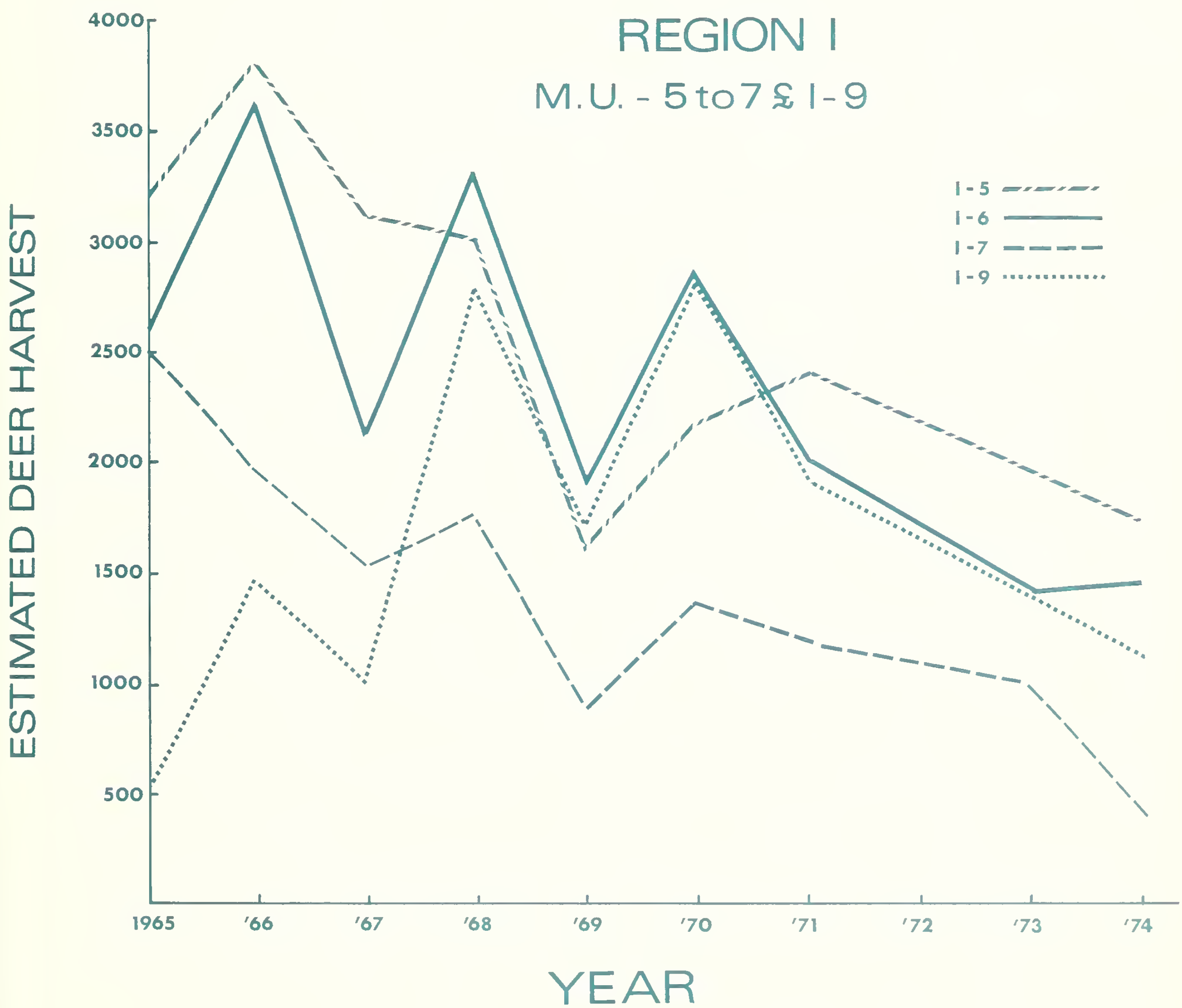

Figure 7--The approximate deer harvest for south-central Vancouver Island deer populations

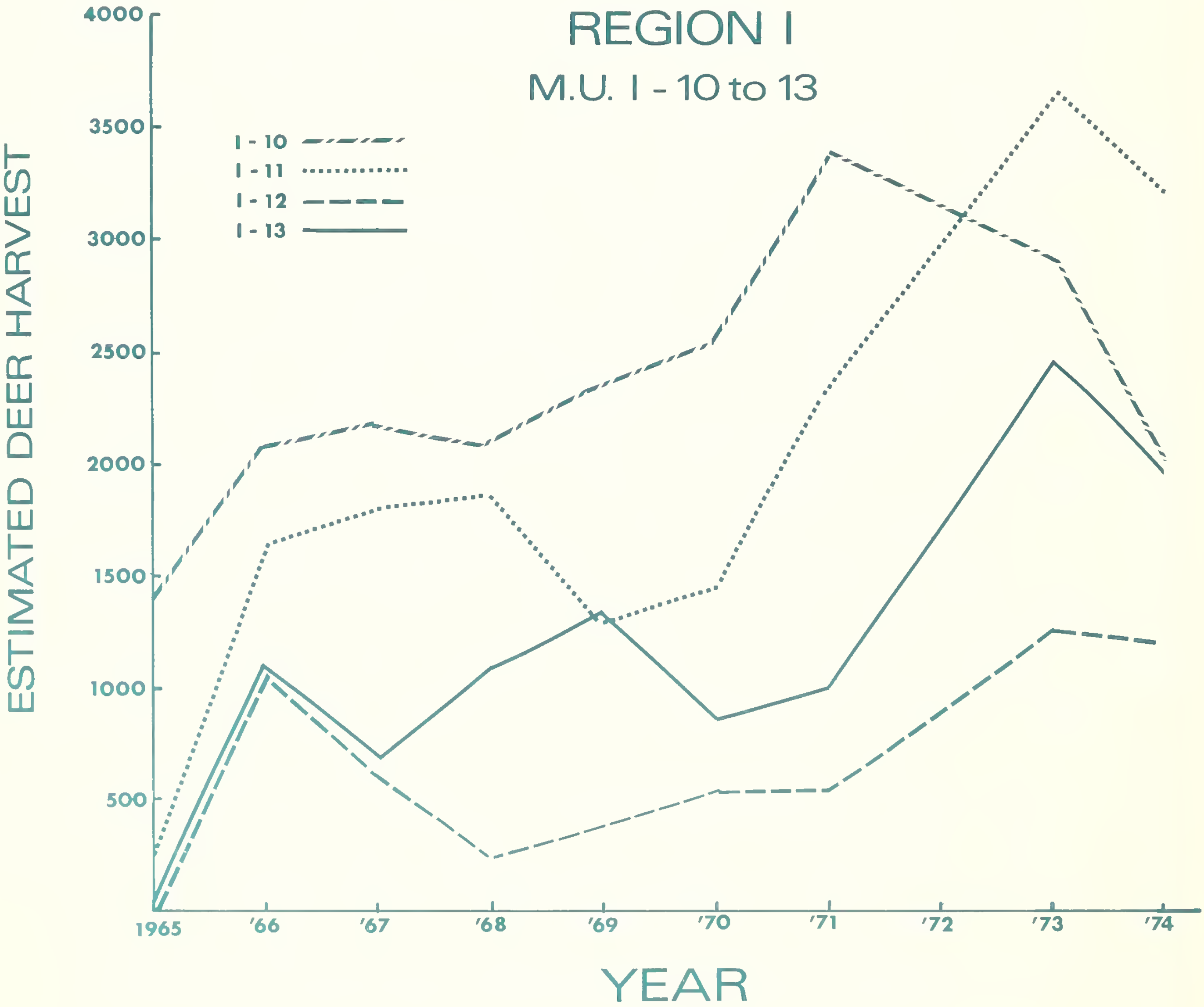

Figure 8--The approximate deer harvest trend for northern Vancouver Island deer populations

Table 2. Estimated deer densities on Vancouver Island watersheds surveyed 1972 to 1977

Watershed	Year	Area[1/]	Amount logged, percent	Mean pellet groups per strip[2/]	Mean pellet groups per plot[2/]	Deer years per square mile[3/]	Sample size
Muchalat River	1976	INT	15	12.9	1.07	63.1	281
Power River	1977	WC	0.1	10.56	.88	52	579
Charlotte Study				9.2		45	
Schoen Lake	1974	INT	10	9.1	0.77	45	140
Memekay	1974	INT-EC		8.0	0.67	39.2	
Klootchlimmis River	1976	WC	nil	6.8	0.57	34	330
White River	1974	EC	10	6.7	0.56	33	722
Tsitika River	1973	EC	nil	6.0	0.49	29	1661
Tsitika River	1974	EC	nil	5.0	0.43	25	2046
Koprino River	1975	WC	nil	4.8	0.40	24	135
Schoen Lake	1974	INT	nil	4.0	0.34	20	108
White River	1972	EC	nil	3.9	0.34	20	678
Tahsish River	1973	WC	nil	3.7	0.31	18	700
Nisnak Creek	1974	INT	nil	3.6	0.31	18	270
Klaskish River	1974	NWC	nil	3.5	0.29	17	426
Stranby River	1974	NC	10	3.1	0.26	15	884
Megin River	1974	SWC	nil	<1.0	<0.09	5	533
Toquart River	1972	SWC	nil	<1.0	<0.09	5	125
Nahmint River	1974	SWC	nil	<1.0	<0.09	5	600

1/ INT = interior, WC = west coast, EC = east coast, NC = north coast, NWC = northwest coast, SWC = southwest coast.
2/ Strips are 6x146, and 6x200 foot belts; plots are 100 square foot circles.
3/ Based on 13 pellet groups per deer per day.

Table 3. Harvest density by management unit (M.U.) on Vancouver Island

M.U.	Area	Harvest 1962-1964[1/]	Harvest 1973-1974
	square miles	-----deer per square mile----	
I-1	265	5.66	2.9
I-2	343.3	9.24	5.33
I-4	567.3	5.24	3.3
I-5	913.5	3.7	2.0
I-6	983.5	3.2	1.5
I-7	863.3	2.6	.85
I-3	996	1.7	.47
I-8	1,158	.02	.09
I-9	770.5	3.15	1.7
I-10	1,180.5		2.10
I-11	736		5.0

1/ Approximate harvest peak.

Table 4. The change in total deer harvest on two logged watersheds on southern Vancouver Island; data from gate access records.

Period	Northwest Bay	Nanaimo Lakes
	--------annual average harvest--------	
1960-1963	521	423
1970-1973		145
1974-1975	150	
Percent change	72	66

certain management units during 1972-1974. However, harvests have been sustained and the populations have had a stay of execution in 1975-1977 due to a series of extremely mild winters. It can be predicted that the next moderate to severe winter will produce drastic declines in harvest success and black-tailed deer populations in general, on the northern part of the Island.

Declines in deer harvest and population size are closely correlated with dense second-growth forests regenerating upon original mature timbered deer ranges. Recent work has indicated that availability of arboreal lichen is approximately 25 times greater and ground story vegetation is 2 to 3 times greater on mature timbered winter range than in second-growth forests 20-110 years of age (main examination in the Douglas-fir zone) [W. Kale, University of British Columbia, personal communication].

In the upper elevation areas of Vancouver Island, mature timber and associated concentrations of arboreal lichen (*Alectoria* spp.) are essential to survival for wintering black-tailed deer. According to Bunnell [1979], arboreal lichen was the second most common constituent of the diet for deer collected in the timber, winter litterfall of lichen is approximately equal to the production of rooted forage, and, the major constituent of the lichen litterfall has an *in vitro* digestibility of 75-90 percent.

Examination of available black-tailed deer information from Vancouver Island indicates that deer populations inhabiting the coastal plain (fig. 9) areas of low-snowfall and low-elevation respond positively to planned timber harvest operations [Hebert, 1976], similar to deer populations in Washington and Oregon. However, the majority of Vancouver Island black-tailed deer populations inhabit mountainous terrain, affected by extremes in winter climate, and require mature forests as critical winter range.

The physiography of Vancouver Island indicates that 2 planning processes are needed to satisfy the habitat requirements of black-tailed deer. Populations inhabiting the coastal plain can be manipulated by adjusting the temporal and spatial distribution of cover and food [Hebert, 1976] and should respond to controlled intensive forest management practices such as juvenile spacing, fertilization, and commercial thinning. Preliminary information suggests that understory canopies of bracken fern, which often form in spaced stands, could present a problem to the growth of more desirable species. Similarly, deer populations on the drier portions of southern Vancouver Island appeared (especially the Douglas-fir zone in lowland areas) to respond to logging (as evidenced by a harvest density of 9-10 deer per square mile in table 3). They appeared less affected by extremes in winter climate and benefited from natural spacing and openings in the second-growth forests of the dry Douglas-fir belt (as evidenced by a harvest density of 5 deer per square mile in 1972-1974 (table 3) which is similar to peak harvest densities on northern Vancouver Island). The sequence of logging can be partially determined by the successional change in vegetation.

Harvest-density declines do not totally reflect population changes because second-growth forests hinder visibility and, therefore, hunter success. However, deer population levels in the second-growth forests of the Cowichan Valley parallel and closely approximate those of harvest density.

The habitat requirements of black-tailed deer in the interior mountainous area of Vancouver Island [Willms, 1971; Jones, 1974] could be met by defining winter ranges in mature timber and deleting (withdrawing) these ranges from development plans for an indefinite period by 1) reducing the annual allowable cut (AAC), 2) providing migration corridors, and 3) by utilizing rotational logging adjacent to winter ranges in order to maintain forage producing areas. In addition, redistribution of the logging over a larger portion of the watershed for any given period of time, reduction of the

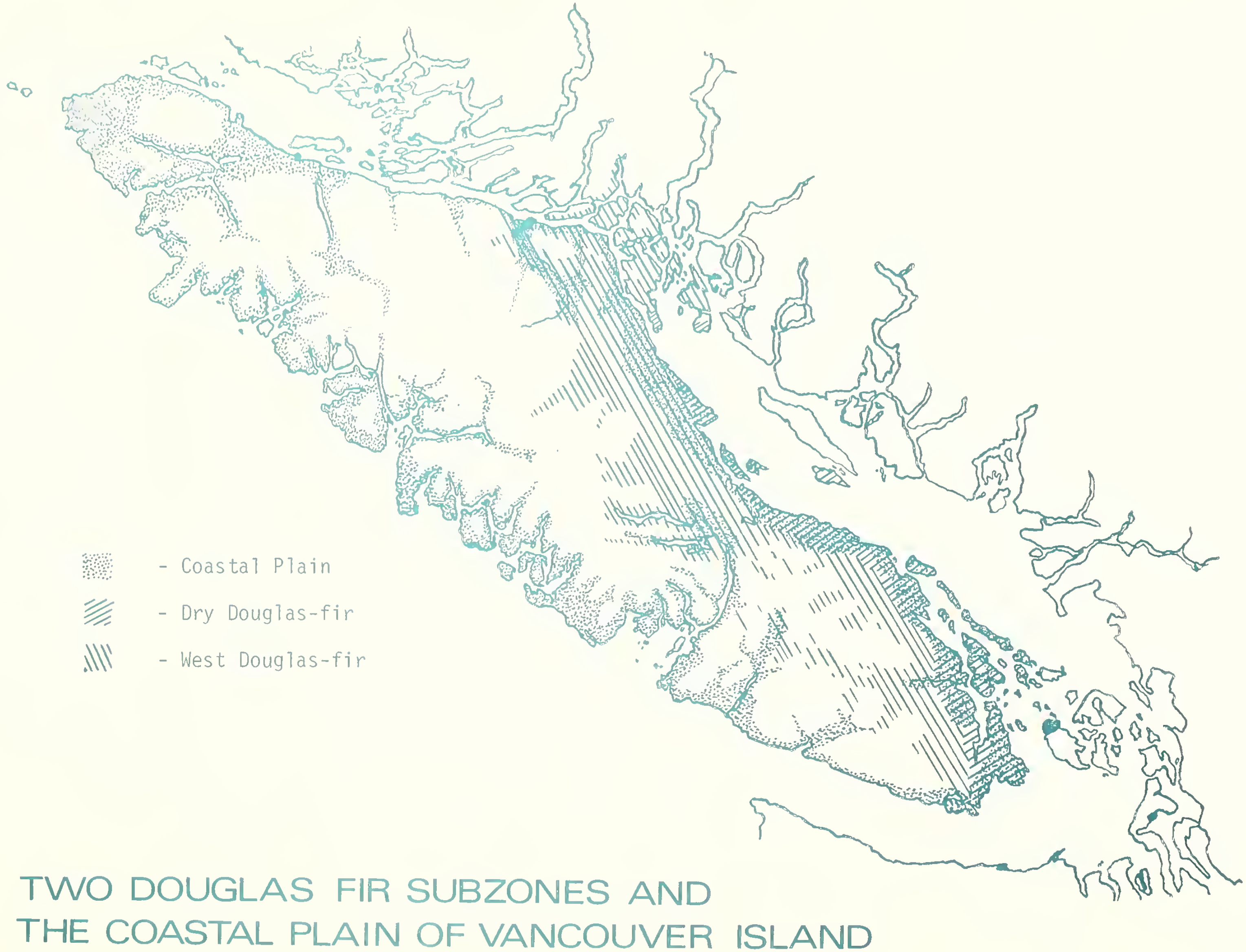

Figure 9--The biogeoclimatic and physiographic basis for planning on Vancouver Island

size of clearcuts, control of cutblock size between south and north aspects, and the extension of greenup for periods of 10-15 years (10-15-foot height class) would also be extremely beneficial.

By comparison, the coastal plain provides only 10-15 percent of the land base of Vancouver Island; therefore, it is unlikely that this area can produce sufficient deer to compensate for population declines and losses experienced in the mountainous portion of the Island. In addition, approximately 88 percent of the coastal Douglas-fir zone within the coastal plain is privately owned by the forest industry and presently provides minimal options for deer management. However, two alternatives will affect the magnitude of deer management within the coastal plain. If forest harvest on the Island is actually proceeding on a sustained-yield basis, there will only be normal pressure on the production of fibre from second-growth forests (increase in human population demand excluded) and, therefore, certain options will be available for the production and management of black-tailed deer [Hebert, 1976]. However, if the sustained-yield concept is not working adequately and the Island is overcommitted and overcut, there will be tremendous pressure to produce fibre from the second-growth forests of the coastal plain and fewer options will exist for the production and management of deer. If bracken fern canopies persist in the understory of precommercially- and commercially-thinned Douglas-fir stands, wildlife productivity will be reduced. This has been observed and noted as a potential problem in experimentally thinned stands in the Sayward forest of Vancouver Island and in certain areas of Oregon [G.L. Crouch, personal communication].

Presently, certain forests of the East Kootenay region of British Columbia (Creston public sustained yield unit (PSYU)) which were managed on the sustained-yield formula have an exaggerated AAC, because the timber that can be reasonably expected to become harvestable falls so short of the physical inventory [Pearse, 1976]. Coastal forests are managed according to the same calculations and formulae and, therefore, the possibility of overcut exists in both the coastal Douglas-fir and western hemlock biogeoclimatic zones.

B. *Government agency interaction*--The second part of the planning process involves the interaction between government agencies (fig. 10). During the period 1972-1977 the planning process has changed from the general coastal guidelines (200-acre cutblock size and 20-chain strips between cutblocks) proposed by the B.C. Forest Service for wildlife protection (with minimal design input by the Fish and Wildlife Branch) to a more comprehensive ecological approach to planning.

A process was initiated during 1973-1974 (review of 5-year development and working plans) to overcome wildlife-forestry problems and has continued to develop into a semblance of a planning process. The 5-year plan review incorporated folio planning in 1975-1976, but, to date the process is incomplete, is not agreed upon by all members, is partially ineffective due to tenure restrictions, and has yet to address the most significant stumbling block to planning: forest policy. Evolution of the planning process is shown in fig. 10. It became evident to both agencies (B.C. Fish and Wildlife and B.C. Forest Service) that planning must include the capability of the land base to produce a commodity (capability analysis), and, the ecological relationship of the land base to timber harvest and silvicultural practice (ecological planning). The process has currently moved into "unit planning" of large public sustained yield unit (PSYU) tenures, but, regardless of the name of the planning phase, it has not effectively curtailed loss of black-tailed deer winter range on Vancouver Island.

Currently, the B.C. Fish and Wildlife Branch is developing better estimates of deer production in coastal plain areas, second-growth areas and interior mountainous areas, and more comprehensive planning of habitat requirements. Simultaneously, the B.C. Forest Service has developed a system of ecological planning [Klinka, 1976]

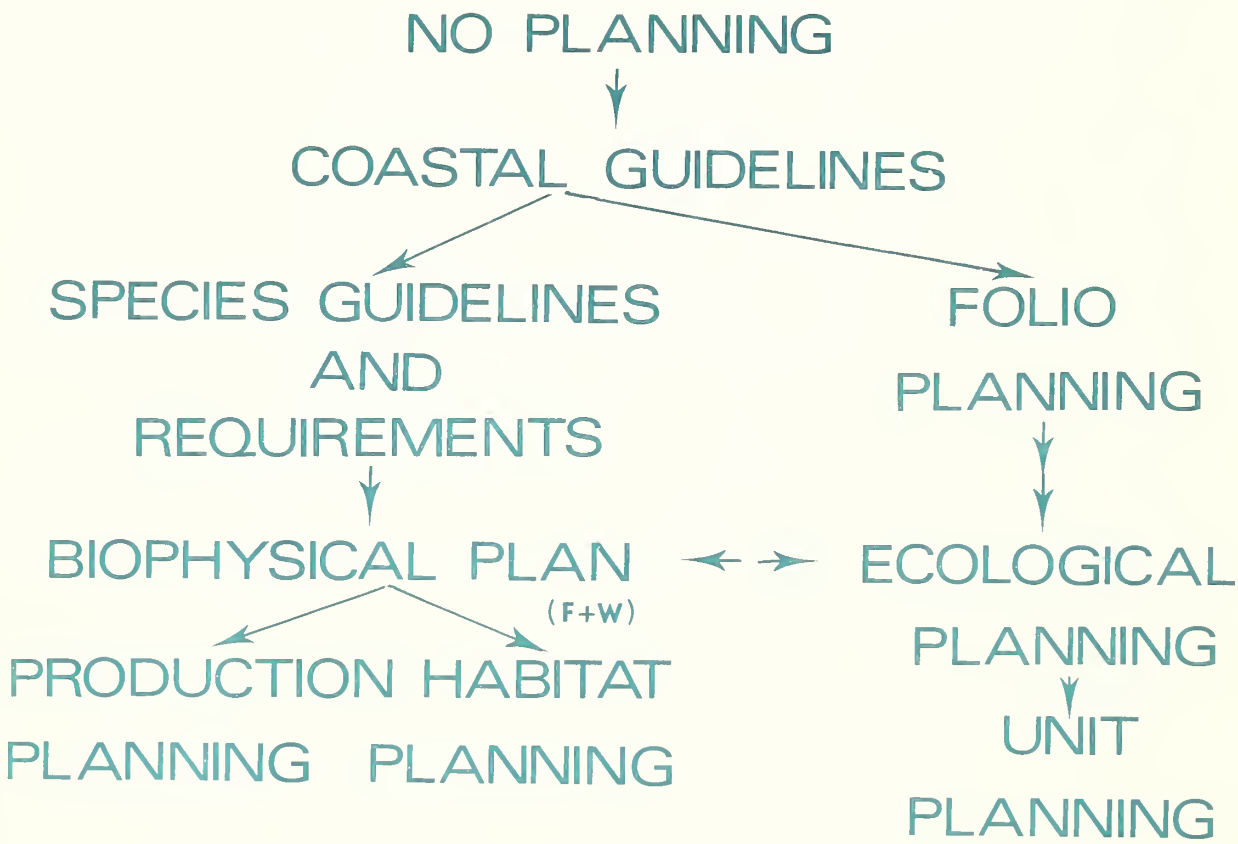

Figure 10--Evolution of the planning process within the B.C. Fish and Wildlife Branch and the B.C. Forest Service

based on moisture regimes, soil types, vegetation associations, and indicator plant species. There is a major problem between the 2 systems. The winter habitat requirements of black-tailed deer depend largely on physical determinants such as slope, aspect, elevation, and climate (snow depth and hardness) in association with arboreal lichen densities, availability of ground story vegetation, litterfall, canopy closure, and associated thermal cover. The ecological system of the B.C. Forest Service relies on moisture, soil, and indicator plant species but relies little on physical components for classification. The higher the correlation between the physical and vegetative aspects, the easier it will be to develop a single classification system. To date, the 2 systems have not been integrated. The classification boundaries in each system may not be relatable (Koprino River, Tsitika River) because of differences in sampling distribution, sampling intensity, and components of classification.

> *Wildlife guidelines.* The B.C. Fish and Wildlife Branch has currently developed a set of guidelines which stratify (fig. 11) Vancouver Island into 5 areas [Davies, 1976] and describe the quantity and distribution of habitat necessary to sustain deer populations at a level below that of a mature timbered watershed. It assumes that if 10 percent of the area below 2,500 feet elevation is retained as winter range, deer population density can increase up to 10 times in these areas. In moderate and severe winters, it is unlikely that these densities are sustainable and, therefore, will decline to only 30-50 percent of the original population. Based on the intensity of past logging practices, the extreme commitment of the forest resource and recognition of the capability of the land to produce deer (exclusive of low capability areas--Management Units I-3 and I-8), and winter habitat requirement of black-tailed deer for mature timber, the present planning process is potentially operable on less than 20-25 percent of Vancouver Island but in an area with the most highly regulated tenure type (TFL).

C. *Resource policy*--The third phase of the planning process involves the agency policy which determines the management of its resource. This part of the planning process is undoubtedly the most important but has evidenced the least input and change to an integrated format. For example, the basic objectives of fish and wildlife (black-tailed deer) management which are NOT being met through the planning process are as follows:

1) To maintain the distribution of the present species complement (that is, stop the space reduction which is now occurring).

2) To maintain the land's capability to support the species complement (this will not occur if mature timbered winter range is harvested).

3) To maintain the abundance of each species based on biological and public demand.

If planning for black-tailed deer is to be successful, the interagency planning process and its policies must reflect the requirements of the species. If they do not, the interaction of 2 renewable resources will produce a NON-RENEWABLE resource. In this case it will be black-tailed deer populations in the interior mountainous areas of Vancouver Island.

At the time of writing, the present Forest Act was being revised but it appears unlikely that changes necessary to effectively manage black-tailed deer will occur in the major policy statements. For example, reductions in the annual allowable cut (AAC) are required for the high deer capability zones 2B, 2C and 3 of Vancouver Island (fig. 11). This should occur on approximately 20-25 percent of the Island's land base according to the wildlife guidelines. In addition, stratification of the

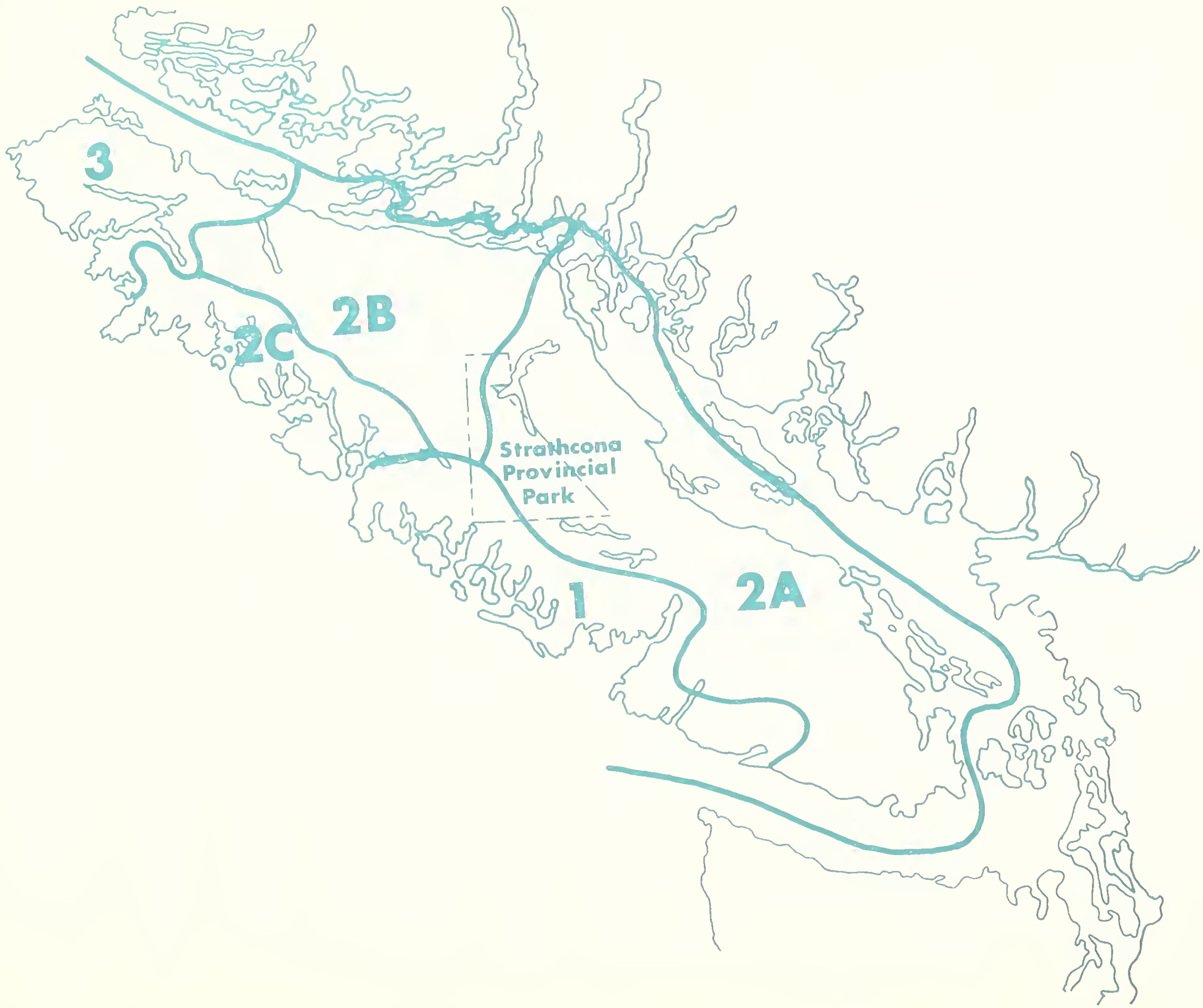

Figure 11--Areas of different ungulate capability on Vancouver Island, according to The Wildlife Guidelines of Region I

AAC must occur below the level of TFL, PSYU, or TSHL, and, it must account for differences between economic regions or large wildlife distribution areas. The main separation at this level should be between multiple-use timber lands and primary timber lands as outlined by Pearse [1976]. Further, there should be stratification at the ecological planning level of biogeoclimatic subzone, biogeocoenoses, and plant association, with consideration given to calculation of an AAC for each watershed or based on site characteristics within each watershed. Similarly, rotation length in high deer capability watersheds should be extended and adjusted to successional time sequences and rotational logging patterns. For example, the 30-year plan for the upper White River incorporates only 1 successional food producing stage of 20 years. Tenure policy (especially TFL policy) not only must reflect timber harvest practices and economic realities but must incorporate more fully the technical realities of an integrated approach to resource management. Greenup policy, which reflects resource integration, is currently lacking but must incorporate silvicultural practice, hazard abatement, and the cover and food requirements of the wildlife resource. Silvicultural policies, which address burning and planting, must be sufficiently flexible (especially within the coastal western hemlock biogeoclimatic zone) to reflect the requirements of black-tailed deer.

Problems arise when current B.C. Forest Service planning statements are contradictory to forest policy in meeting the requirements of the black-tailed deer resource. For example, the B.C. Forest Service states that, "Developing resource strategies is an interdisciplinary task to which the BCFS is strongly committed. Our evaluation of land-use strategies will emphasize the compatability of timber harvesting and other resource uses." In addition, they state, "the purpose of public sustained yield unit planning (PSYU) is to determine the rate of timber harvesting considering timber and non-timber natural resources" [Unit Planning Guide, 1976]. Clearly, these statements represent an attempt to resolve resource conflicts.but they are not supported by a sound interagency planning process, a policy which reflects the requirements of the species or tenures which are sufficiently flexible to allow integrated management.

D. Tenure--A brief description of the tenure types found on Vancouver Island will exemplify the problems facing institution of an efficient integrated planning process.

a) Private land. About 25-35 percent of the Island is composed of privately owned forest land. There is little or no planning control by either the B.C. Forest Service or the B.C. Fish and Wildlife Branch. The main restriction imposed by the B.C. Forest Service is in the form of a firebreak network for fire protection purposes. Interestingly, almost 88 percent of the most productive zone in Canada (coastal Douglas-fir zone) occurs within private land. While 12-15 percent of this forest zone is under Crown control, it is controlled by TFL or PSYU tenure.

b) TFL tenure. The second most important tenure is the Tree Farm License. In this case, the forest company is responsible for the forest inventory and silvicultural practices under a 21-year lease agreement (partially revised in the new Forest Act). Productive land can be withdrawn (Schedule B) at the discretion of the Minister for amounts up to 1 percent of the total land of the TFL.1/ Any amount on non-productive land can be withdrawn by the Minister. To date, there is not an example of a withdrawal of mature timber

1/ Currently 5 percent under the revised Forest Act.

for critical deer winter range. Pearse [1976] suggests that "Although each TFL or PSYU may be managed according to principles of sustained yield, its separate blocks need not be, and so a timber supply region is not assured of a steady harvest or any integrated harvest control." In exactly the same manner, it lacks regulation of integrated resource management for wildlife.

c) TL tenure. Although comprising a relatively small proportion of Vancouver Island, Timber Licenses presently preclude integrated planning because the timber is owned by the company. The timber rights revert to the Crown after the initial harvest; however, where TL land encompasses deer winter ranges there is little or no opportunity for withdrawal and little chance for deer production in second growth forests when TL land occurs between 1000- and 2600-foot elevations. Where TL land is incorporated as part of the TFL tenure, withdrawals for wildlife range must be initiated by the company and compensation (usually monetary) must be paid by the government.

d) PSYU and TSHL. These tenures make up a small proportion of Vancouver Island but allow integrated planning to a larger degree. Inventory, silviculture and determination of AAC are determined by the Crown. The EPA (environmental protection forests) program is being applied in these tenures in an attempt to reduce the AAC for the benefit of wildlife. These tenures are limited in number and distribution, generally do not contain the highest capability deer areas and recently B.C. Fish and Wildlife recommendations for EPA removals for black-tailed deer were reduced considerably.

Policy Control

Tenure description indicated the large degree of control by the timber industry. Procedures, policy and legislation were developed to maximize fibre and economic returns in an era when integrated management was nonexistent. Until about 1970, the economic growth responsibilities of government and the policy interaction between government departments showed little responsibility toward integrated management. Presently, consideration of the requirements of the wildlife resource, the agency planning interaction and the integrated utilization of natural resources is proceeding (fig. 12); however, its development will be controlled by government's conception of economic growth responsibilities. The policy interaction which bridges the two components is controlled by economic growth and, in turn, controls integrated resource management. Too often, this model operates as a passive, trial and error procedure rather than as an active process attempting to incorporate integrated management and efficient long-term utilization of the resource base.

A striking comparison exists between southeast Alaska and Vancouver Island (fig. 13). Although Alaska is approximately 100 years behind British Columbia in its timber harvesting, its black-tailed deer population will suffer for similar reasons:

1. a carryover of biological reasoning from the 1950s and from areas with different climatic regimes (Oregon, Washington, southern Vancouver Island);

2. an inadequate interagency planning procedure;

ECONOMIC + GROWTH

RESPONSIBILITIES

↓

POLICY

INTERACTION

↓

REQUIREMENTS

SILVICULTURE, WILDLIFE CAPABILITY

↓

AGENCY INTERACTION THROUGH

PLANNING

↓

INTEGRATED UTILIZATION OF RESOURCES

Figure 12--The relationship between the technical aspects of integrated management and economic growth policy

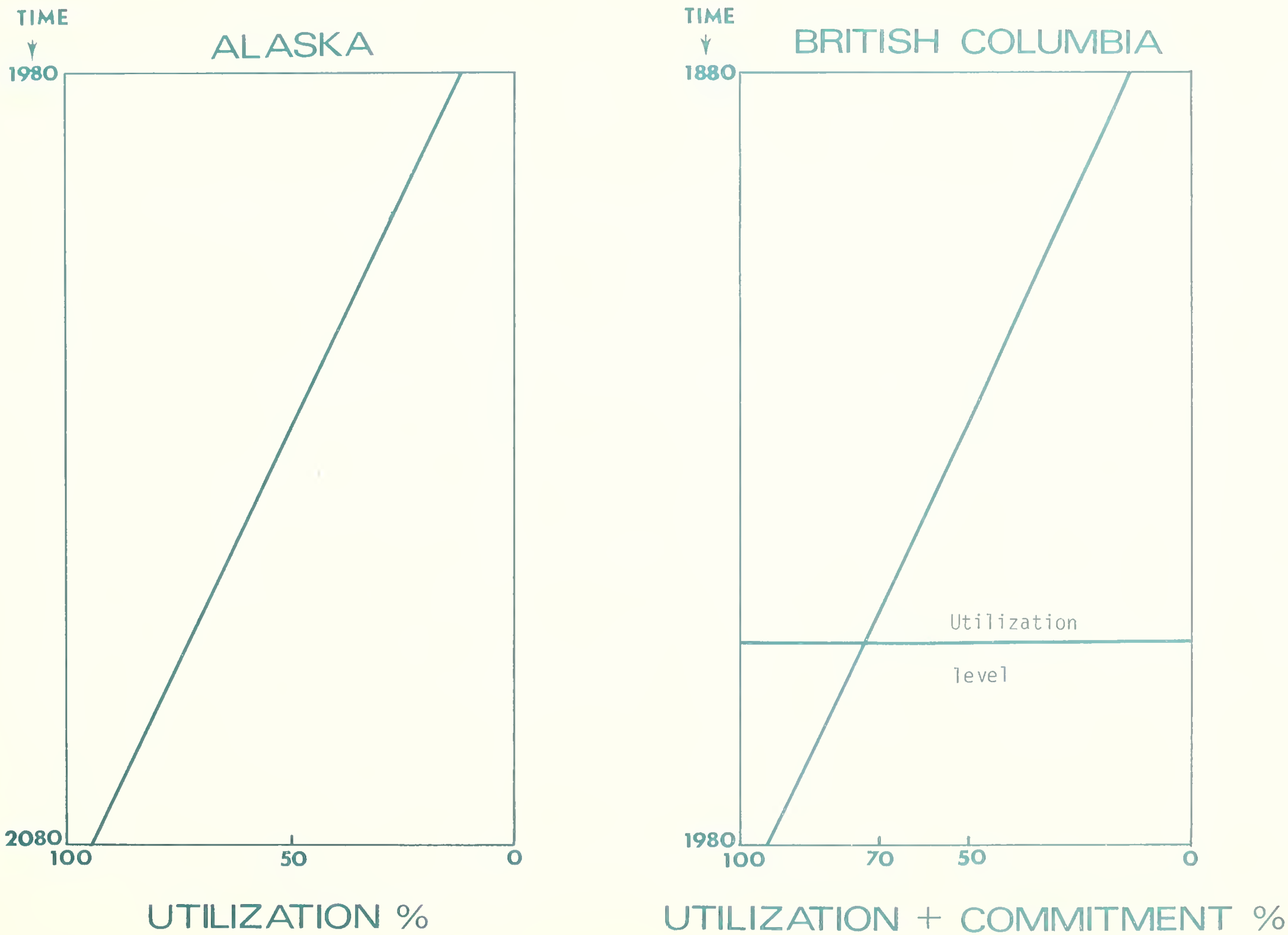

Figure 13--A comparison of the level of commitment and utilization between Alaska [adapted from Schoen and Wallmo, 1978] and Vancouver Island, B.C.

3. policy which does not reflect the requirements of the wildlife species; and,

4. a commitment to harvest the timber resource (economic growth responsibility) which precludes adequate resource integration.

In order for wildlife agencies to participate in the present planning process they must accept (actually plan for) large declines (50-90 percent) in black-tailed deer populations. If the planning and policy process continues in the present form, many deer populations in the interior mountainous areas of Vancouver Island will cease to exist. Currently, it can be predicted that the deer harvest on northern Vancouver Island will continue to decline and the decline will be hastened by the next moderate to severe winter. It is also likely that the magnitude of the decline will be considerably greater than that experienced on southern Vancouver Island.

Discussions during this conference suggest that, although the words integrated management are being used by both the U.S. and B.C. Forest Services, the process does not adequately incorporate the habitat requirements of black-tailed deer. The process cannot be considered integrative if the entire forest resource of southeast Alaska is allocated to wilderness areas, native land claims, and long-term leases to the forest industry, and, if that of Vancouver Island is 90-100 percent committed to the forest industry, with 70-75 percent already harvested.

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Populations, Harvests, and Their Management

This section deals with regional and temporal fluctuations in deer populations and harvests and, to a lesser degree, on how they are estimated. Because several of the papers consider causal phenomena, they also touch upon some apparent habitat problems. Two papers deal exclusively with methodology. The one by Gordon Fisch discusses a germinal effort to evaluate factors influencing the applicability of pellet-groups counts, so far our most promising technique for estimating relative and absolute population densities. The one by Warren Ballard, Harry Merriam, and Patricia Copock, evaluating methods used to estimate harvests, was not presented at the conference, but the authors felt--with full concurrence from the editors--that it was most germane to these proceedings.

The Life and Times of the Black-tailed Deer in Southeast Alaska

by

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Introduction

The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), like any creature of the wild, has its share of problems as it struggles to maintain its place in the sun. Occupying natural habitats at the extreme northern edge of black-tailed deer range, and in some cases transplanted to ranges beyond, it becomes much more vulnerable and sensitive to the variety of factors affecting its numbers. These factors, operating singly or in combination with each other, weave an intricate pattern of life and death characterizing the life and times of the Sitka blacktail.

The status of deer populations is of great interest and concern to people in southeast Alaska, despite the fact that if every deer disappeared for one reason or another we would probably get along just fine. The current deer situation is one of the most popular subjects of conversation in southeast Alaska in almost any circumstance. One needs only to sit quietly in almost any bar, coffee break at the office, house party, or barber shop and before long the conversation turns to deer, their problems, and, of course, all the answers for successful management! And thus it is, we as game managers who work for these people must strive to understand not only what these factors are and how they affect deer populations, but how the knowledge can be used to better manage deer and their habitat--if for nothing more than to insure the public a continuing topic of conversation!

The purpose of this workshop is to pull together what is known about deer in southeast Alaska; in a sense, an overview. Thus, I would like to review what has been done so far concerning natural mortality patterns with primary emphasis on winter mortality, since winter weather appears to be the major factor affecting deer population levels. Of course, weather must be considered in context with existing population levels, range conditions, predation, and levels of parasitism and disease.

Discussion

The first attempts to assess mortality patterns of deer in southeast Alaska were discussed by Klein [1957] and expanded upon by Klein and Olson [1960]. This work dealt primarily with the effects of starvation caused by snow depth and range conditions, accidental mortality, and sex and age differences in winter-killed deer. Between 1951 and 1956, deer populations generally increased, following a period of heavy winter mortality in the late 1940s, and over-stocked ranges occurred in some areas. Winters were generally mild with the exception of the winter of 1955-56, which was colder and developed with local heavy snow accumulation in late winter. Conclusions thus far indicated that:

1. Starvation accounted for 80 percent of winter losses. The remainder were due to predation, accidents, and miscellaneous causes.

2. On ranges in good condition, fawns comprised 84 percent of the loss in 1956 (example, Petersburg-Wrangell and south Admiralty areas); on heavily-used ranges, fawns comprised 40 percent and deer over 5 years old 50 percent of the mortality (example, Sitka-Peril Straits).

3. Deer in the 1-1/2- to 5-year-old range usually comprise less than 10 percent of the winter loss. Therefore, 5 years seems to be an approximate upper limit of physiological efficiency.

4. Sex composition of deer 5+ years old was 18 males:100 females, which suggests heavier mortality of males in all age classes.

5. The effects of wolf predation on deer populations where speculated upon but there were few data upon which to draw conclusions. It did seem apparent that, on the mainland and islands south of Frederick Sound where wolves occur, deer populations were increasing rapidly, ranges were in fair to good condition, and winter mortality was fairly light. In comparison, on the wolf-free islands northwest of Frederick Sound, deer populations were more stable or only slowly increasing and exceeding the carrying capacity of some winter ranges.

Merriam [1970] essentially updated our previous studies in his paper, *Deer Fluctuations in Southeast Alaska*, presented at the Northwest Section meeting of the Wildlife Society in 1970. Among other things, he reviewed the lows and highs of deer abundance between 1918-1969, discussed effects of disease and parasitism, hunting pressure, wolf predation, and winter mortality during the period 1957-1969.

Low deer population levels apparently occurred in 1918, 1925, 1934, 1943, 1950, 1956, and 1969. Deer were more abundant between these dates with the last peak between 1961-1963. Deer numbers declined beginning in 1964, and in 1969 populations were the lowest since 1950. Deer populations are capable of recovering to previous levels within 4-5 years. Black-tailed deer in Alaska are generally quite free of disease and parasites and their numbers do not seem to be limited by these factors, although they could be contributing factors during severe winters when resistance is lowered due to starvation.

Analysis of age data from hunter-killed deer through 1969 indicated that hunting has had no significant effect on age classes. Levels of deer abundance were similar in hunted and non-hunted areas.

Preliminary examination of wolf/deer relationships resulted in conclusions that deer population cycles have occurred both on wolf-inhabited and wolf-free areas in

southeast Alaska although not always simultaneously. Wolves can control deer numbers on smaller islands (as demonstrated by the introduction of wolves on Coronation Island) and can accelerate declines on larger islands, but predation by wolves alone is not a limiting factor.

Merriam [1970] again demonstrated that winter weather is the primary limiting factor on deer abundance and that the availability of food and productivity are secondary factors influenced by weather. There was definite correlation between average winter temperatures and deer winter losses. Fewer losses occurred in winters averaging 32° F or higher than in winters averaging below 32° F (fig. 1), and success of hunters in the following hunting season reflected these differences.

Prolonged, excessively-cold weather, requiring greater food intake, and compounded by long periods of persistent, deep snow restricting availability of food, results in increased winter losses of deer due to starvation. Browse alone will not sustain deer. If snow cover prevents availability of ground forbs for long periods, malnutrition occurs, does produce less fawns, and deer are more susceptible to other decimating factors such as predation.

There are indications that deer may become adapted to climatic conditions. Although weather conditions in northern portions of southeast Alaska are more severe than in the south, deer populations show the same cycling tendencies. Average winter temperatures and conditions in Prince William Sound resulting in little loss of deer would produce severe losses in southeast Alaska.

Thus far:

1. *Weather*--Winter weather, primarily prolonged periods of cold (below average temperature 32° F) combined with continuous snow cover sufficient to reduce availability of browse for long periods, causes greatest winter losses. The generally severe winters in the mid-60s, followed by the most severe winter on record (1968-1969) produced the greatest losses of deer.

2. *Age*--Fawns and deer 5+ years old are most susceptible and comprise 80-90 percent of winter mortality.

3. *Sex*--Male and female fawns are equally susceptible. In the 1-1/2- to 5-year-old range, males are more susceptible. Among deer over 5 years old, females are more vulnerable. Losses of more males during prime years means proportionally more females survive beyond 5 years. Thus, more females show up as winter kill in the older age group.

4. *Predation*--Wolves can control deer numbers on small islands, accelerate decline of deer numbers elsewhere, and delay recovery to former populations levels.

It appears that the winter of 1968-1969 was a turning point in the life and times of deer in southeast Alaska. This is where the cumulative effect of all mortality factors definitely changed things for deer depending on what region they inhabited. Although the basic patterns seem to persist, somehow the net result has not been the same in various areas of southeast Alaska.

First of all, since 1970-1971, with local exceptions, winters have been less severe with several open winters culminating with the winter of 1976-1977, one of the mildest on record--the antithesis of 1968-1969. One would expect, in view of

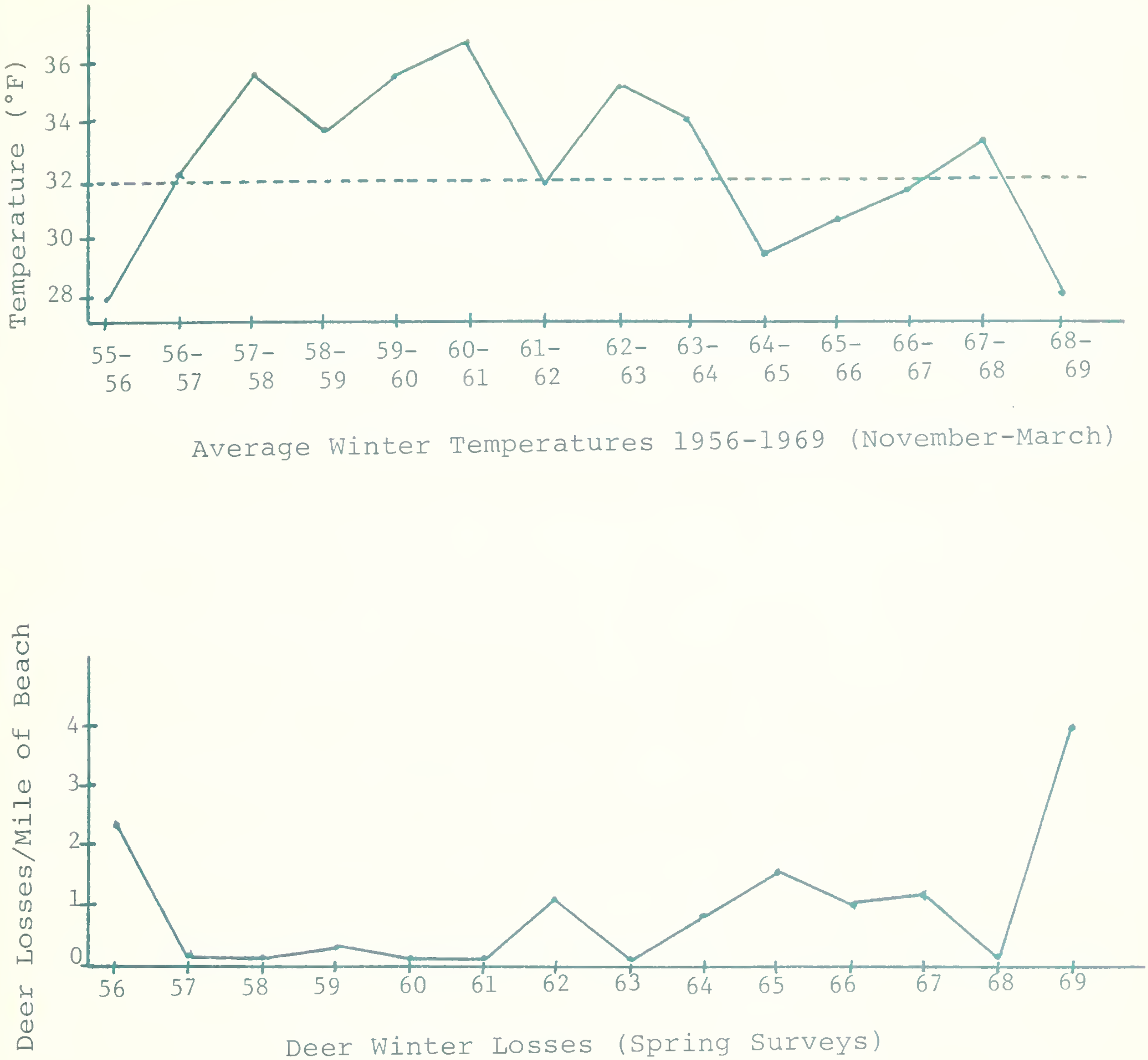


Figure 1--Comparison of winter temperatures and deer winter losses in southeast Alaska, 1956-1969. From Merriam [1970].

experience thus far, that deer populations should be all coming back to previous levels of abundance--not so! Inquiries were addressed to Area Game Biologists for information on recent population trends and their causes.

Bob Woods reports that in the Ketchikan area deer numbers are remaining static at low levels. There has been little or no winter mortality, particularly in the last 4 winters. Populations are below the carrying capacities of the range. Predation and hunting appear to be the only major mortality factors; however, it must be noted that deer numbers also remain low in areas of light or no hunting pressure.

In the Petersburg area, Harry Merriam reports that, after a series of relatively mild winters and negligible winter mortality, deer populations are at an all-time low. Hunter harvests dropped from 3,700 in 1961 to 40 in 1974, and in 1976 the season was closed! Deer are almost absent from some of the larger islands such as Kupreanof. Winter mortality now is very low--no deer to die! The primary mortality factor now appears to be wolf predation.

The reproductive capacity of the existing deer population is apparently incapable of overcoming the predation exerted by wolves. Similar to the Ketchikan area, deer numbers are also low in areas not subject to heavy hunting. Thus, it appears at this point in time that predation may have superceded weather as a primary mortality factor. So, the pattern changes in a sense. Which is worse, lack of deer due to weather, or no deer due to wolves? I think, perhaps, it is not a matter of "which is worse," but more not really knowing all we could about how these patterns evolve.

On the north end of their range, mild winters have also prevailed and, finally, deer populations are on the "up" side in the Juneau area, responding as expected, according to reports from Dave Johnson. In the Sitka area and ABC islands, deer numbers are again high, according to Loyal Johnson. Winter losses have been low to moderate, overall less than 1 deer per mile of beach and almost no losses in the winter of 1976-1977. Hunter success on the islands has been high (60-80 percent). Winter ranges are showing chronic heavy use in many areas.

In general then, deer populations are low and static in southern Southeast, despite mild winters, insignificant winter losses, and no seeming effect from hunting pressure. In central Southeast, record low populations persist despite increasingly mild winters, low hunting pressure and understocked ranges. Both areas are experiencing predation from wolves. At the north end of the range numbers are increasing, populations are high, and winter ranges are showing chronic heavy use. Wolf predation is absent except perhaps on some mainland areas. Immediately there is the question, "How come?" "Why?" Are there any significant changes in the mortality patterns?

There is not much information upon which to draw. It is possible, however, to make a few comparisons between what Klein [1957] and Merriam [1970] presented in the 1950s and 1960s and data from northern southeast Alaska (ABC Islands) for the 1970s, following that disastrous winter of 1968-69. The data in table 1 indicate that fawns comprise most of the mortality over time. This is similar to what Klein and Olson [1960] showed for the 1950s under similar circumstances for all of southeast Alaska (table 2). As mentioned previously, Merriam [1970] showed that when average winter temperatures dropped below 32° F, losses began to reach 1 or more deer per mile of beach. This same pattern is apparent for Unit 4 (fig. 2). The extremely mild winter of 1976-1977, with record high temperatures, resulted in no observed mortality of deer. As might be expected, hunter success subsequently improved.

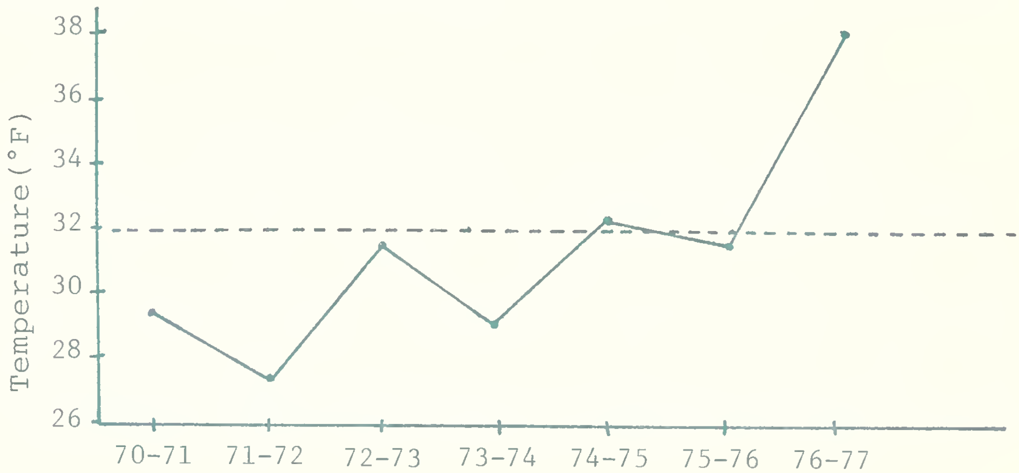
Winter mortality patterns thus continue to assert themselves much as they always have. I don't think we have learned much that is new over the years with perhaps one or two exceptions. These are the effect of wolf predation and spatial distribution of deer on winter range.

Table 1. Proportions of fawns and adults among 92 winter-killed deer in Game Management Unit 4 (Admiralty, Baranof, Chicagof, and Kruzof Islands), 1971-1977. From Alaska Department of Fish and Game [1975]

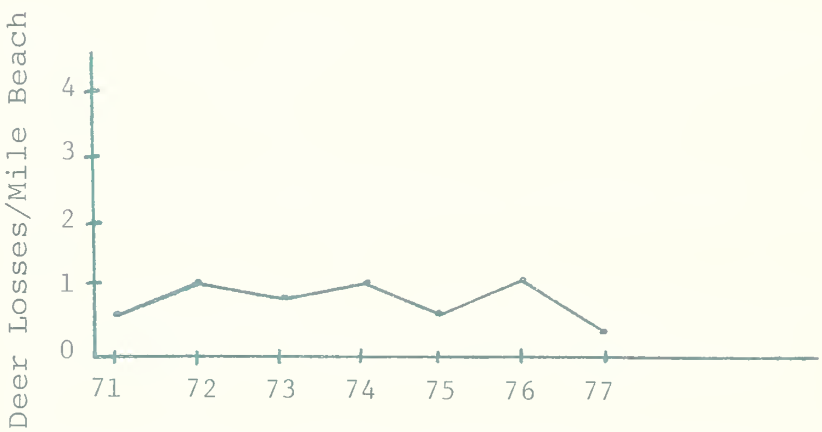
Year	Fawns number	Fawns percent	Adults number	Adults percent	Total
1971	9	47	10	53	19
1972	10	43	13	57	23
1973	13	100	0	0	13
1974	9	75	3	25	12
1975	1	17	5	83	6
1976	9	47	10	53	19
1977	no mortality				
Total	51	55	41	45	92

Table 2. Proportions of fawns and adults among 323 winter-killed deer from southeast Alaska, 1952, 1954-1956. From Klein and Olson [1960]

Year	Fawns number	Fawns percent	Adults number	Adults percent	Total
1952	60	75	20	25	80
1954	18	39	28	61	46
1955	37	58	27	42	64
1956	66	50	67	50	123
Total	181	56	142	44	323



Average Winter Temperatures 1971-1977 (November-March)



Deer Winter Losses on Admiralty, Baranof, Chichagof and Kruzof Islands (GMU4), 1971-1977 from spring surveys

Figure 2--Comparison of winter temperatures and deer winter losses, Game Management Unit 4, southeast Alaska, 1971-1977

At first it appeared that, except for smaller islands, wolves did not have much impact on deer population levels. It now appears that wolf predation does have a significant impact. At what point wolf predation becomes a critical factor capable of either depressing a population or actually eliminating it, is not well understood. Beyond the fact that it happens when a high deer population, which has supported a high wolf population, suffers a series of heavy winter losses, we don't have much to go on. Merriam's work on Coronation Island [Merriam, 1965, 1970] has provided considerable insight concerning the effect of wolf predation on small islands--primarily that they are capable of reducing deer populations to extremely low levels. We are, however, much in need of information on how this mortality factor operates wherever wolf and deer occur together. Until it is known at what point and under what circumstances predation becomes a significant factor, any attempts at managing the situation will be haphazard at best, and this particular part of the natural mortality pattern will be a continuing problem. Of course, the social aspects of handling wolf predation problems lend yet another dimension to be considered.

One more part of the pattern that should be mentioned briefly is the fluctuation of numbers relative to population distribution. Although all deer populations are subject to weather, the greatest fluctuations are experienced on the inner islands of southeast Alaska. Mainland populations, though seldom as high as island populations, seem to be more static over a period of time. This is probably due to the fact that winter conditions and other mortality factors are uniformly more severe and populations seldom build to excessive levels.

Summary

In summary, we understand the following aspects of natural mortality of deer in southeast Alaska:

--Certain sex and age classes predominate in the winter kill.

--The availability and condition of forage on key winter areas influence winter mortality.

--Temperatures and the extent and duration of snow cover are critical factors.

--Wolf predation can reduce numbers and delay population recovery following heavy winter losses.

--Hunting pressure appears to have little overall effect on deer population levels.

What we don't really know are how the combinations of factors interact and at what point things become critical. What are the key indicators and what can managers do to anticipate problems and situations created by natural mortality. We have added little to our knowledge in the last 15 years.

It is time we examine the various programs underway and decide if they are adequate to provide the information needed for management. For example, the various survey techniques and procedures used to assess range condition and winter mortality could stand improvement; they haven't changed much over the years. Perhaps some modeling is necessary to better understand the interaction of various combinations of mortality factors.

I have only scratched the surface of this subject. Thus, I think it is time to take a detailed look at natural mortality of our Alaska deer populations. It is interesting to look backwards, but more important to look forward, and plan our approach to future deer research and management in Alaska.

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Deer Harvests in Southeast Alaska

by

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and

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Introduction

The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) is indigenous to the islands of southeast Alaska and the mainland to about the latitude of Juneau. For game management purposes, this area is described as Alaska Game Management Units 1-4 (fig. 1): the mainland and Revillagigedo Island is Unit 1 and has 4 subdivisions; Unit 2 is Prince of Wales Island; Unit 3 is the Petersburg-Wrangell area including Kuiu, Kupreanof, Mitkof, Wrangell, Zarembo, Etolin and adjacent islands; and, Unit 4 is Admiralty, Baranof, Chichagof, and Kruzof Islands (the ABC islands). Deer are less abundant on the mainland than the islands, and populations are more stable on the ABC islands. Presently deer are in low to very low numbers everywhere except on the ABC islands. Deer were transplanted to Yakutat, Unit 5, in 1934 [Alaska Game Commission, 1935], where they are currently at low levels.

Sitka black-tailed deer experience population fluctuations of large magnitude [Merriam, 1970]. Others at this conference will discuss the biology of these fluctuations. Whatever the reason, be they long-term of unknown cause or short-term, weather-induced highs and lows, these fluctuations are of singular importance to the harvest of deer taken in Alaska.

Discussion

Most hunters are residents of southeast Alaska. Hunting pressure, as indicated by license sales, has been fairly constant in most areas with an overall increase in Juneau and Ketchikan. The hunting season usually opens August 1 and runs through December 31, with local exceptions. The limit is up to 4 deer, with antlerless deer

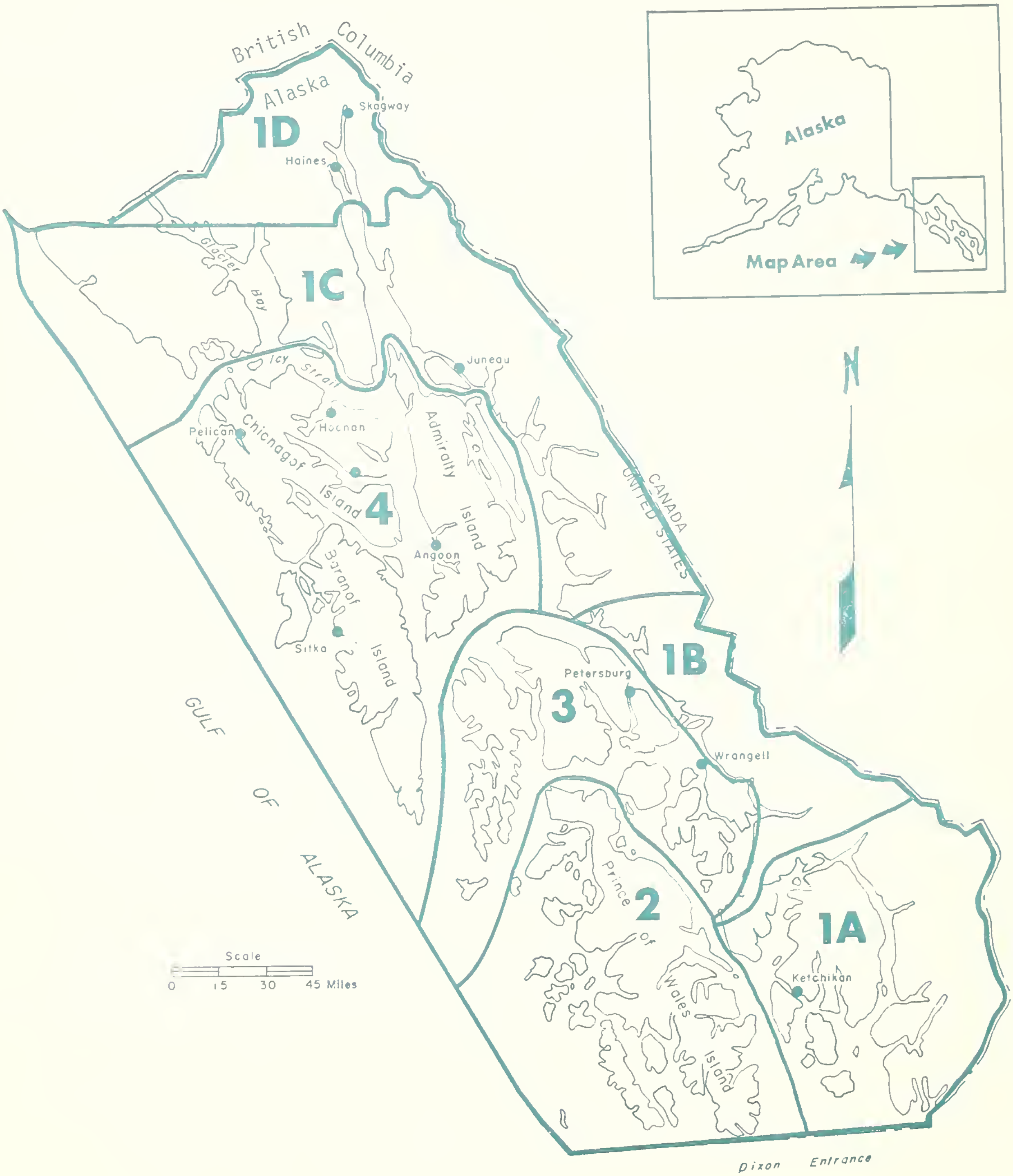

Figure 1. Game management units of southeast Alaska

legal after September 15, again, with local exceptions. Deer may not be taken with the aid of a helicopter in any manner, nor can they be taken from a boat or while they are swimming.

Deer hunting in southeast Alaska can be broken into 3 periods dictated by the deer's seasonal habitat use. The first period is August to about mid-September. Hunting is usually done in the alpine and is restricted to bucks only. This is a high quality, outstanding style of hunting. It can be rather difficult, because of weather and terrain, so accounts for less than 4 percent of the total harvest.

The second period is from about mid-September until snowfall. Deer are on their intermediate range, generally in big timber, just below alpine, after frost kills succulent summer forage. Calls are very effective and hunting is for deer of either sex. Again, this is a very high quality hunt, and it is an effective hunting period for those who know how to hunt them. This period contributes about 10-15 percent of the harvest.

The third period begins after snow has restricted deer to their winter range. Calls are again effective, especially if snow coincides with the rut. There is a great deal of hunter effort because deer are most available, and upwards of 80 percent of the annual harvest is taken during this time. Ethical and sporting considerations are not as high as during earlier portions of the season. It is primarily a meat hunting period.

Sometimes extreme snow makes deer very vulnerable, which poses problems of ethics and sportsmanship. This puts the manager in a "rock or hardplace" position, for the early, heavy snow which contributes to a high hunter kill also may be a precursor of high winter mortality--the combination of which can reduce the deer population. It is ironic that severe winters, when heavy mortality occurs (both natural and hunter kill), are often followed by mild, open winters. During the latter, deer are not visible on beaches nor are they concentrated on winter ranges. The public has often interpreted the apparent lack of deer during the mild years as a result of mismanagement from heavy hunter kill during the previous severe winter.

We might also add a fourth period, the year-long "gunny sack" season, which in remote areas is of some consequence. There are 2 primary motivations for hunting deer: for sport and for meat. In former times or in times of high deer populations, many residents of southeast Alaska looked upon the Sitka blacktail as their primary source of red meat. That was true until about 1968 when the current downward trend became pronounced. It is still possible for many people, especially residents of Sitka, Angoon, Pelican, Kake, Hoonah, Tenakee, and other communities in or near Unit 4, to utilize deer for their meat needs. These people can and do hunt from their back door. This is a matter of choice and/or tradition, not necessity, but the resource can support it, so people do it. But, hunting for Sitka black-tailed deer also affords a very high quality sporting experience. Still-hunting, calling, or stalking in the alpine for these animals can be among the most enjoyable forms of big game hunting. The meat of the Sitka blacktail is of very excellent quality, so meat derived from such a hunt is of secondary, but still high, importance. Residents of towns and areas where deer populations are now low (that is, Petersburg, Wrangell, Ketchikan) still hunt deer, but local deer numbers are not sufficiently high to provide a significant meat source. Consequently, many of these people hunt Unit 4. Such trips, however, are costly and are usually a once-a-year affair. If a man takes 10 days away from work, spends $500, and shoots 4 60-pound deer, call his motivation for hunting what you want, but in no way can it be a financially-rewarding meat hunt.

Note that we did not call those who hunt for meat "subsistence" hunters. Subsistence hunting is a very complex issue in Alaska today and one subject to much debate.

Here we are referring to people whose use of established deer seasons and bag limits is primarily for the purpose of obtaining venison.

Harvest Measurements

Since statehood we have used 2 techniques in Alaska to measure deer harvests: hunter interviews and harvest tickets. In about 1959, a post-season hunter interview was initiated and conducted annually until 1974. It was based on a sample of about 10 percent of the men licensed to hunt and was done in Ketchikan, Wrangell, Petersburg, Sitka, and Juneau. The Big Game Harvest Ticket system was expanded in 1968 to include deer. A comparison of results from both methods, used concurrently for 3 years, led to a decision to drop the interview in favor of the harvest ticket in 1974. However, an interview sample was taken in Sitka in 1975.

Both systems had their shortcomings and both had their merits. The interview probably gave a more accurate assessment of the total harvest, was more timely, the cost was insignificant, was handled at the local level, and provided a good opportunity for personal contact with hunters; something we have too little of. However, it was biased by virtue of not sampling the smaller communities, and it had the usual biases of an oral interview. After some years of repetition, it became an unpleasant task, which may also have affected the results.

The harvest ticket, which is required of everyone who hunts deer, reaches a much larger sample and should, theoretically, provide more accurate data. It is very costly, provides only limited data on unsuccessful hunts, and since deer harvest data is low on the Division of Game priorities, is very untimely in being analyzed (normally no earlier than August of the following year, if at all). Compliance in returning the harvest ticket has averaged only about 60 percent. Harvest ticket returns have, however, proven very useful in providing hunter effort and harvest figures on specific areas for use in assisting the Forest Service in land-use planning.

The importance of timely, reliable harvest information, regardless of the species involved, is a basic prerequisite for any resource managing agency. This is especially true at this point in time with deer management, as there are so many demands on the limited deer habitat in southeast Alaska. For our own management needs it now appears that the hunter interview, with modification, would be the most useful.

Magnitude of Harvests

The earliest record we found of deer harvests in southeast Alaska was a recent translation of a Russian report [Pierce and Donnelly, in press] that the native people of Sitka sold 2,774 deer (the translation called them goats) to the Russian settlement in Sitka in 1861. During the 1940s and 1950s, as reported by the Alaska Game Commission and U.S. Fish and Wildlife Service (in-service annual reports on file in Alaska Department of Fish and Game headquarters library), the annual harvest ranged from 5,000 to 15,000 deer.

From 1959 to 1968, based on hunter interviews [unpublished Alaska Department of Fish and Game records], there was an annual kill of about 10,000-12,000 deer (fig. 2). Reduced harvests normally follow a severe winter with high natural mortality and hunter kill, but can also occur in a snow-free year when deer do not become vulnerable. A good example of the latter is 1976, while 1969 and 1972 are good examples of the

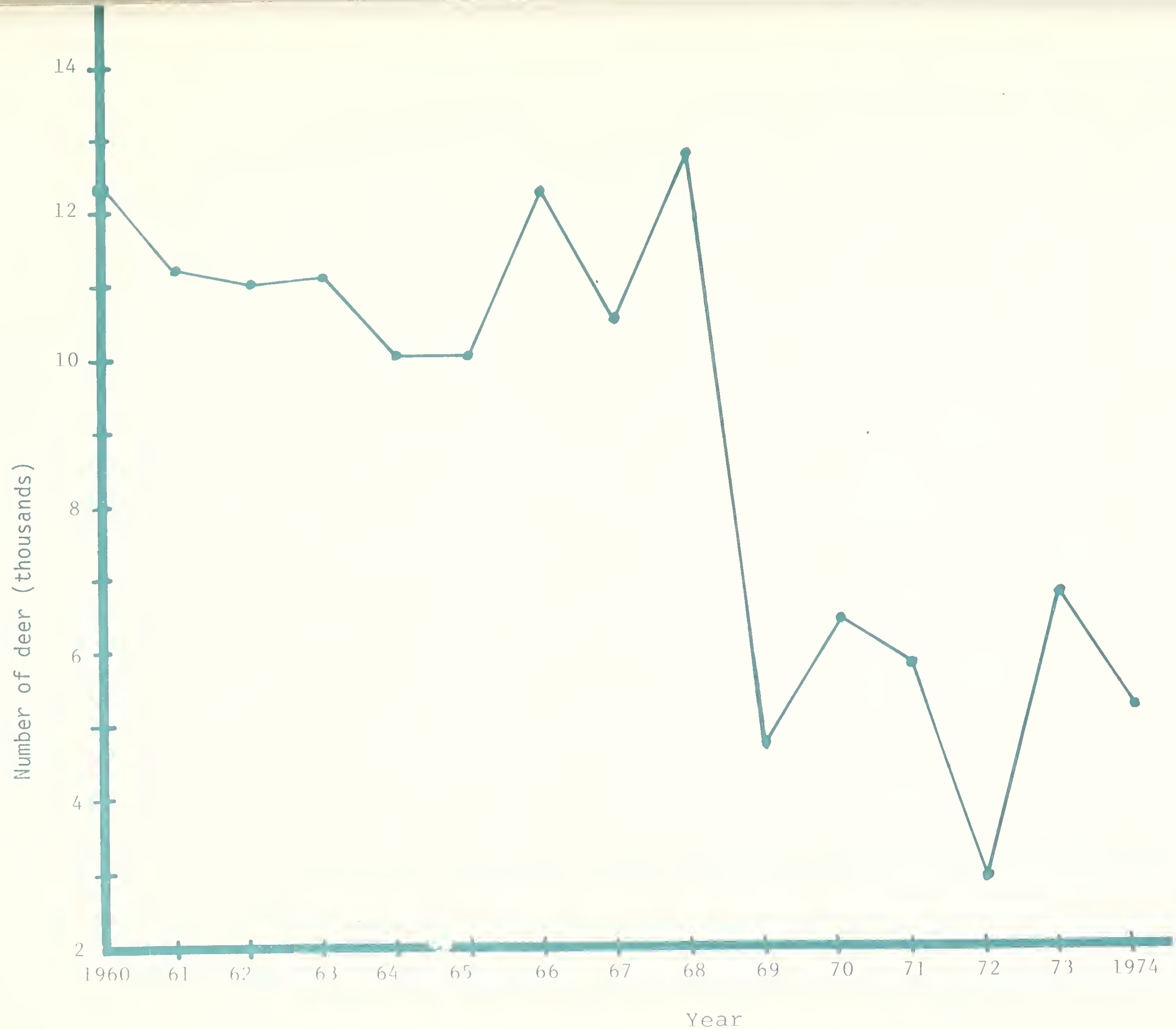

Figure 2. Annual deer harvests estimated from hunter interviews.

Figure 3. Deer harvest by hunters from major cities, estimated from hunter interviews.

former. Season extensions have also occurred, which account for some of the peaks. As fig. 2 also shows, the current population low in all areas, except Unit 4, has brought the overall harvest down considerably.

Normally about 75 percent of the hunters take at least 1 deer, but the average kill per hunter is around 2 deer. During good or average years hunters expend about 3 days effort per deer taken. Not surprisingly, unsuccessful hunters expend only about 1/3 the effort expended by successful hunters. Bucks have traditionally made up about 60 percent of the harvest. Once again, the current population status and the attendant restrictive regulations have altered these generalities.

By community, residents of Sitka normally harvest about 2,000 deer annually, of which 70 percent come from within a 30-mile radius of the town. Ketchikan hunters took about 3,000+ deer annually prior to 1968, mostly from the immediate Ketchikan area. Currently, they are taking around 500 deer, of which about 20 percent come from Unit 4. Juneau hunters annually take from 2,000-5,000 deer, 60 percent of which come from Admiralty Island. Petersburg hunters, prior to 1968, took about 1,000-2,000 annually, usually within the local area; today they take about 200-500, mostly from southern Admiralty Island. Wrangell hunters took about 600+ annually before 1968, mostly local, but now take about 100, mostly from Admiralty Island. We really don't know much about deer harvests from the outlying communities where contacts with Department personnel are infrequent and compliance with harvest ticket requirements is low.

Weather has the greatest impact on southeast Alaska deer harvests. This is the result of population reduction from winter mortality and/or hunter kill or invariable deer vulnerability. As noted above, without superimposing this over the above harvest figures, these figures can be somewhat misleading.

Outlook

History has shown the Unit 4 deer population to remain high and stable. We should be able to maintain or perhaps increase harvests as human populations increase and more people hunt more remote areas. It is inevitable that the increasing human population and increased mobility will force a curtailment of the present liberal season and bag limit so that fewer people can rely on deer for meat. The kill can remain at present levels; however, it will be shared by more people. Deer populations will undoubtedly recover farther south so that those areas will, again, support a higher harvest. It is doubtful, though, that we will again see a limit of 4 deer and a 5-month season over much of southeast Alaska because of today's feelings of ecological awareness, citizen involvement, antihunting, and the like. Major habitat modifications will undoubtedly result in reduced populations and, therefore, reduced harvests. Then, too, the conflicts of land ownership and classifications, preferential uses by certain groups, and land-use practices, combined, will place additional uncertainties on regulated harvesting by the general public as a deer management tool.

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History and Current Status of Sitka Black-tailed Deer in Prince William Sound

by

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Introduction

Deer are not native to Prince William Sound. The Cordova Chamber of Commerce in 1916 arranged to have 8 black-tailed deer (*Odocoileus hemionus sitkensis*), captured near Sitka, transplanted to Hawkins and Hinchinbrook Islands in Prince William Sound. From 1917 to 1923, 16 more blacktails were added to supplement the original transplant. The introduction of deer to Prince William Sound was the initial big game transplant in Alaska and has proven to be one of the most successful [Burris and McKnight, 1973].

The browse in Prince William Sound was not being utilized by any ungulate when deer were introduced. Thus, the deer responded rapidly to the virgin habitat--they increased rapidly and dispersed throughout Prince William Sound wherever suitable habitat existed. The population peaked about 1945 and by 1950 range damage was severe, drastically reducing the carrying capacity of the winter range [Robards, 1951]. Extreme population fluctuations are common with most species at the northern limits of their range; Prince William Sound deer are no exception. Major die-offs were recorded in the late 1940s, mid-1950s, late 1960s, and early 1970s. Winter snow depth and duration is the primary regulating factor of deer abundance in Prince William Sound.

Discussion

Distribution and abundance--The distribution of deer in Prince William Sound is fairly stable and what observable, though slight, expansion and retraction of range utilized by deer is the direct result of the severity of previous winters. A series of mild winters allows deer to expand their range only to be reduced by the next normal or severe winter.

In Prince William Sound, the better deer populations are found on the larger islands: Hawkins, Hinchinbrook, Montague, LaTouche, Green, Knight (eastern side) and the Naked Island group (fig. 1). The mainland is marginal deer habitat with the exception of the Gravina Point to Rude River area which contains a moderate deer population. The northern and western portion of Prince William Sound is marginal habitat. Prince William Sound fishery biologist J.D. Solf, now deceased, stated [personal communication] that he had seen deer or deer tracks in nearly every major drainage of Prince William Sound at one time or another. Each year deer are reported in atypical areas around Prince William Sound, but winter snow depth does not allow them to become established.

Hawkins, Hinchinbrook and Montague Islands support probably 70 to 75 percent of the Prince William Sound deer population. No attempt to estimate total numbers of deer in Prince William Sound has ever been made. The current deer population would be classed at a moderate-to-low level compared to the carrying capacity of a "normal" winter.

Harvest--Deer hunting in Prince William Sound commenced in 1935. The regulations made it legal to take 1 buck having antlers not less than 3 inches in length, from September 20 to September 30, under a special permit prescribed by the Secretary of Agriculture. The drainages into Prince William Sound open to hunting were: north of the center of the Copper River and Northwestern Railway and west of Mountain Slough, including the islands of Prince William Sound, except Hawkins and Knight Islands.

In 1938, the regulation stipulated that only residents could hunt. In 1952, after a major die-off, the bag limit was raised to 2 bucks. Does became legal in 1953 and fawns a few years later (1955?). Season lengths, bag limits and areas open to hunting varied from year to year, but gradually increased until 1964 when the Game Management Unit 6 (Prince William Sound) deer season was set for August 1 through December 31 allowing 4 deer per year, provided that antlerless deer could only be taken from September 15 through December 31. The season and bag limit has remained the same for the past 14 years.

Good harvest data are not available. Presently, 2 methods of collecting harvest data are utilized: harvest report cards and Cordova hunter interviews. Deer harvest tickets have been required since 1965, but hunter compliance in returning the harvest report card has been poor. For Game Management Unit 6 the harvest report card data probably give a fair picture of the overall harvest; that is, percent of males, number of deer taken per hunter (1, 2, 3, or 4), deer per hunter plus chronology and location of the harvest. Harvest report card data have not accurately reflected the magnitude of the harvest or the hunting effort (days hunted). The 1977 harvest report card was modified to better reflect hunting effort. The Cordova hunter interview, which is conducted annually by interviewing 100 Cordova hunters and extrapolating the results, gives a fairly reliable picture of the deer harvest by local hunters. But, the interview data probably give a distorted "overall" picture of the harvest. Local hunters probably kill more deer with less effort than those from Anchorage, Fairbanks, and Kenai Peninsula, but they are also very lax in returning their harvest report cards. The number of deer reported taken by Cordova hunters (interview data) is often larger than the harvest indicated by the statewide harvest report card.

The Unit 6 (Prince William Sound) deer harvest varies from about 500 to 1,500 deer per year. Hunters that go afield average slightly more than 1 deer and average 3 to 4 days per deer. Hunter success is variable, but normally better than 50 percent. Snow conditions influence the magnitude of the harvest more than the size of the deer population.

There appear to be 2 basic types of deer hunting: 1) hunting in alpine areas early in the season prior to deep snow, and 2) hunting in the lowlands after snow has

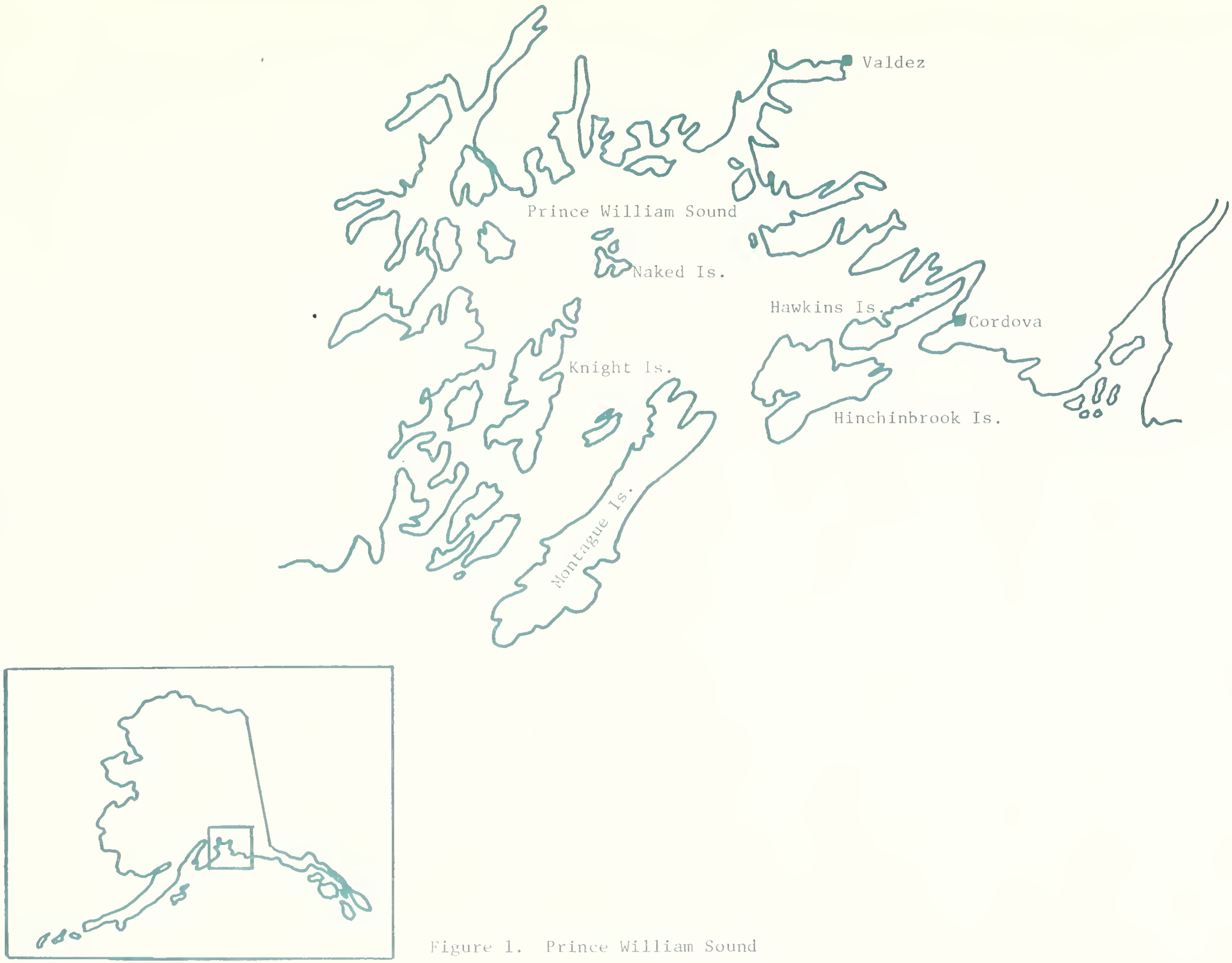

Figure 1. Prince William Sound

concentrated the deer on or near the beaches. The alpine hunter is the avid hunter who hunts for the sport and for the meat. The late-season, deep-snow, hunter is more interested in meat than sport, and may not hunt if deer are not pushed to the lower elevations by snow.

Hawkins Island receives the majority of early season hunting pressure. Once snow concentrates deer in the lower elevations, hunting effort shifts to Hinchinbrook and Montague Islands. The other major deer islands are also normally hunted at this time but to a lesser extent. Local (Unit 6) hunters tend to be more meat- than sport-oriented and probably account for about half of the Unit 6 deer harvest. They commonly utilize commercial fishing boats for transportation and lodging. They are mobile and are able to hunt when and where conditions are optimum. The visiting hunter primarily hunts for sport and concentrates on Montague and Hinchinbrook Islands where Forest Service cabins are available. Less than 5 percent of the Prince William Sound hunters are non-residents.

Habitat--Prince William Sound deer are dependent upon climax forest vegetation rather than sub-climax habitat which is considered their normal relationship in the "lower 48." A climax forest provides the essential shelter and forage necessary to survive through the winter months. Deer could not survive in Prince William Sound without a climax forest along the beach fringe.

Prince William Sound deer have a fairly small home range that includes vertical migrations with the changing seasons. A 3-1/2-year-old doe ear-tagged during March, 1967 in Port Etches was killed by a hunter on the same beach 10-1/2 years later in November, 1977. Most likely this deer had moved up and down the same drainage for the past 13 years. The greatest documented movement of an ear-tagged deer in Prince William Sound was a female fawn tagged in February, 1968 at Double Bay, Hinchinbrook Island. It was killed in November, 1971 at Juania Bay, Hinchinbrook Island, a straight line distance of 9 miles. No major geographic features separate the tagging and kill sites.

Food is not a limiting factor during the snow-free portion of the year. Some of the more abundant plants utilized by deer are *Cornus canadensis* (bunchberry), *Rubus pedatus* (trailing bramble), *Coptis asplenifolia* (gold thread), *Maianthemum dilitatum* (false Lily-of-the-Valley), *Lysichiton americanum* (Yellow Skunk Cabbage), and *Vaccinium ovalifolium* (blueberry). Realistically, kelp should also be listed as a major food item for Prince William Sound deer.

During the summer, deer may be found at any elevation but the preferred habitat is at or above timberline. This alpine range is characterized by lush meadows of *Maianthemum* in small openings of hemlock at timberline or dwarf hemlock above timberline. In the fall after frost kills the *Maianthemum*, deer move down into the high timber country where *Cornus*, *Rubus*, and *Coptis* are abundant. During the winter, deer remain just below the snow line, moving up and down with the changing snow depths. They continue to feed on evergreen forbs until snow forces them to utilize woody plants, with *Vaccinium* being the most important. Usually they are near the beach when *Vaccinium* becomes their staple diet. As *Vaccinium* becomes scarce they turn to kelp for the bulk of their diet. If forced to remain on the beaches for an extended period, approximately 2 months, winter mortality commences. The beach and timbered beach fringe is the most critical habitat to Prince William Sound deer. Snow depth forces deer to lower elevations until there is no place to go except onto the beach. Deep, rutty trails, sometimes shoulder deep to the deer, are formed between the tidal beach and the beach fringe timber. Their life evolves around feeding on kelp at low tide and scrounging food under the climax canopy along the beach fringe at high tide. Critical winter range is often less than a 100-yard-wide strip of forest parallel to the beach. If snow conditions are not too severe they may range inland approximately 1/4 mile. Prince William Sound's deer winter range is poor in quality.

It has been overbrowsed periodically since the late 1940s and will never support a large deer population, as compared to the early 1940s. Only after a series of mild winters during which deer are not forced onto the beaches for an extended period of time, will they become "abundant."

The only practical way to preserve critical winter deer range is to refrain from disturbing the climax forest [Leopold and Barrett, 1972]. In Prince William Sound, this means no logging within 1/4 mile of winter deer range beaches. Also, forested areas above the critical winter range to 500 feet elevation should be maintained. This area provides critical relief from the beach fringe during late fall and early spring.

Browse utilization and range condition data were collected from 1964 to 1970 in a cooperative effort by the U.S. Forest Service and Alaska Department of Fish and Game. Ten range transects were established in Prince William Sound to determine browse utilization annually on key winter ranges. The technique utilized is described in the Alaska Department of Fish and Game Annual Segment Report, Project W-6-R-3, Work Plan A - 1e. This method employed 1/2 mile transects parallel to the beach fringe consisting of 20 permanently marked *Vaccinium* plants. Data on the number of browsed and unbrowsed leaders, plant height and condition, plus deer winter mortality, were taken annually in the spring. The browse utilization study was dropped in 1971 because the data collected gave an erroneous impression of winter range conditions. A severe winter would show relatively little utilization of *Vaccinium* because it was covered with snow. A mild winter would show the same percent utilization because deer were not forced onto the winter range for any duration. It is interesting that the 7-year average for *Vaccinium* utilization (annual leader growth) was 61.2 percent with annual fluctuations from 30.2 percent to 82.0 percent. Presently, no range studies are being conducted.

Mortality--There are 2 major sources of mortality to deer in Prince William Sound: 1) starvation and 2) hunting. Starvation is by far the greatest cause of mortality; but occasionally, hunting can have a significant effect upon the deer population.

This past winter (1977-1978) proved to be an example of how deer hunting can affect the population. Heavy snow fall in early November forced deer onto the beaches and basically held them there through December. The winter appeared to be a repeat of the 1971-1972 winter when an estimated 80 percent of the Prince William Sound deer population was lost through starvation. Fortunately, hunting conditions were good in November and December and hunters took large numbers of deer off the beaches. By late December hunters were taking deer which contained little or no fat. Warm weather (wind and rain) in January, 1978 caused the snow to recede from the beach fringe timber, making available the abundant *Cornus*, *Rubus*, and *Coptis*. A field reconnaissance trip in late January revealed little winter mortality, but utilization of *Vaccinium* was estimated at 80 percent of the previous year's leader growth. In addition, extensive use of alder (*Alnus*) and rusty menziesia (*Menziesia ferruginea*) was noted. Rusty menziesia has rarely been utilized by Prince William Sound deer in the past except for an occasional bite or two; only the young *Menziesia*, about 2 feet tall, had been browsed. The extensive use of *Vaccinium*, *Alnus*, and *Menziesia* indicated that by the end of December deer were desperate for food. Had the deer harvest not been heavy, and in some areas almost excessive, considerable winter mortality would have occurred before the warm weather in January made feed available. This past winter was not typical. Usually the deer are not concentrated on the beaches during the hunting season long enough for a significant harvest to occur, and the majority of winter mortality through starvation would occur in late winter or early spring.

The magnitude of winter mortality in Prince William Sound is difficult to determine. Snow depth at the high tide line during a severe winter may be 4 to 6 feet. Deer that are weak often die on the beach and are gradually carried off by the next series of high tides.

Predation is not a significant problem to Prince William Sound deer. The majority of deer are found on the larger Prince William Sound islands which have no wolves or coyotes. Brown bear is the only large predator on Hinchinbrook and Montague Islands but is usually in hibernation during the critical winter months. A few coyotes are present along the mainland in deer country (Gravina Point to Rude River) and probably take their toll of deer during periods of deep snow. A few deer are present near the town of Cordova. They fall easy prey to dogs and coyotes when snow depth restricts their mobility.

Disease has never been a problem to Prince William Sound deer. In fact, they are probably the most disease and parasite-free big game species in Alaska. Occasionally a deer with "warts" will be taken by hunters. These probably are fibromas or papillas --usually benign tumors. Only 3 to 4 cases have been reported in the past 9 years.

Management--Deer management in Prince William Sound has been largely a matter of maintaining liberal seasons and bag limits, and letting the hunters harvest what they could. The deer season has only been altered twice since 1964. In January, 1967 the season was extended by 2 weeks (with an increased bag limit of 2 deer of either sex) because large numbers of deer were concentrated on the beaches. In 1973, the season was closed 2 weeks early by emergency order because of the large harvest that had occurred with a relatively small deer population.

According to the "Alaska Wildlife Management Plans" [Alaska Department of Fish and Game, 1976], which have not formally been approved by the Board of Game, the Prince William Sound deer management goal is "to provide the greatest opportunity to participate in hunting deer." The opportunity to participate is deemed more important than success or quality of the hunt.

The management philosophy at present is to maintain the liberal season and bag limits because hunting has little effect upon the deer population. The season will be closed by emergency order only when a small deer population exists coupled with a potentially excessive harvest. Rather than harvest all the animals that might die of starvation, their fate will be dependent upon a warm trend occurring in mid-winter. If the deer population is "high," the season will remain open regardless of the magnitude of the harvest. Prince William Sound deer range will never support a large deer population except following a series of mild winters, so with a high deer population the hunters might as well harvest all they can.

Except in extreme cases, hunting has little effect upon the status of Prince William Sound deer populations. Winter snow depth and duration are the controlling factors. Preservation of the habitat is the best management possible at present.

Summary and Conclusions

Problems--The most critical problem facing deer management in Prince William Sound is maintaining their winter range, namely preserving the climax forest within 1/4 mile of the beach. In southeast Alaska, it has been estimated that a clearcut will take at least 200 years for a new forest to reach the climax stage where forage is again available to deer [Schoen, 1977]. Once the climax forest along the beach fringe is clearcut it is essentially lost as deer habitat forever. In the past,

little conflict between logging and deer habitat has occurred in Prince William Sound because the timber sales were small and not in critical deer habitat. In addition, the Forest Service has been fairly responsive to Alaska Department of Fish and Game suggestions. Native selection of lands for timber resources in eastern Prince William Sound could result in a loss of deer haibtat. Also, native and D-2 land selections could force the U.S. Forest Service into selecting deer habitat for future timber sales.

Another potential problem is oil contamination of kelp on critical winter beaches. If an oil spill should occur dring a critical period when deer are subsisting on kelp, it could be detrimental, perhaps fatal if they are in a very weak condition. A possible solution might be to have the oil company responsible feed the animals until the oil can be cleaned off the beaches.

Predation could also pose a threat to Prince William Sound deer. Wolves were not common residents of the Copper River Delta until recently. The introduction of moose to the Delta during the 1950s and their rapid increase in numbers and distribution, coupled with existing goat populations, has provided a food base. If wolves should become established in Prince William Sound on the major deer islands, they would drastically affect deer abundance. Deer would be extremely vulnerable to wolf predation in most winters because of the very narrow and limited winter range.

The future-- .e future of deer in Prince William Sound is neither good nor bad. Deer have existed in the Prince William Sound region for over 60 years. They have dispersed throughout the South and occupy all suitable habitat. Thus, it is a "stable," established population that is likely to be around for a good many years if their habitat is protected.

Hunters must be made aware of the limited winter range and that Prince William Sound deer abundance will fluctuate considerably with the severity of future winters. It is not a realistic possibility to improve the forage along the beach fringe, nor is it economically feasible for the State to feed deer during the winter months as is done in some West Coast states.

A baseline study of deer dependency upon the beach and beach fringe timber, as influenced by snow depth and duration, would be extremely beneficial in better understanding and anticipating population fluctuations. At present, the future of Prince William Sound deer rests in maintaining the climax forest along the beach fringe.

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History and Current Status of Sitka Black-tailed Deer in the Kodiak Archipelago

by

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Introduction

In the Kodiak Archipelago, populations of the introduced Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) inhabit vegetative associations quite distinct from deer ranges in the rest of Alaska. Deer populations are still expanding into previously unoccupied or lightly occupied ranges. Concurrent with this range expansion, a decline in the population in areas first occupied by deer is evident. The direction of deer management has evolved from a protective phase, through a conservative phase, and into an exploitive phase as deer populations have expanded. This paper will review the history of the transplant and subsequent pattern of occupation of the Kodiak Archipelago by deer. Deer/habitat relationships, natural mortality, harvest patterns, and management problems will also be discussed.

Description of area--Karlstrom [1969] provides an accurate description of the topography, climate, and geology of the Kodiak Archipelago. The Archipelago is a group of islands extending 177 miles in a southwesterly direction off the southern tip of the Kenai Peninsula (fig. 1). The area is mountainous with maximum elevations above 4,000 feet. The 2 largest islands, Kodiak and Afognak, are characterized by steep bluffs descending into numerous long glacially-scoured straits and fiords. The islands in the Archipelago cover an area of approximately 5,000 square miles. Seldom do temperatures fall below 0° F and average annual precipitation is about 60 inches, although much local variation in rainfall and temperature occurs.

The vegetation of the Kodiak Archipelago can be classified into 3 major types. Batchelor [1965] describes the Sitka spruce (*Picea sitchensis*) type which covers Afognak, Shuyak, Raspberry, and much of northeastern Kodiak Island. Most of Kodiak Island is dominated by a grass-brush type. Alder (*Alnus sinuata*) stands are interspersed with dense meadows of salmonberry (*Rubus spectabilis*) and grass (*Calamagrostis canadensis*). Cottonwood (*Populus balsamifera*) and birch (*Betula kenaica*) occupy valleys and lower foothills. Approximately the southwestern quarter of Kodiak is occupied by tundra vegetation of willows (*Salix* spp.) and heath plants, including

Figure 1. Location map of major islands in Kodiak Archipelago, Alaska.

crowberry (*Empetrum nigrum*), bearberry (*Arctostaphylos uva-ursi*) and low cranberry (*Vaccinium vitis-idaea*). Hulten [1969] described this vegetative type in detail.

Discussion

History of transplant and population trends--Fourteen deer, captured in the Sitka area, were released in 1924 on Long Island, about 4 miles east of the town of Kodiak [Burris and McKnight, 1973]. Two more deer were placed there in 1930. A small population of deer became established on this spruce-forested island approximately 3 square miles in area. Although reports are sketchy, apparently it was intended that deer moving from Long Island would eventually stock Kodiak Island. Long Island is separated from Kodiak's mainland by some smaller islands and deer would have to swim a maximum of 1 mile between adjacent islands. A 1931 Alaska Game Commission report mentioned that 3 does and 2 bucks had been seen on Kodiak. An additional transplant seemed appropriate and in 1934 4 bucks and 5 does were released on Kodiak Island. If the 1931 Game Commission report was accurate, deer had probably already become established on Kodiak when the 1934 transplant was accomplished.

The Long Island deer population was estimated at 80 deer in 1938, according to Palmer [Rhode, 1948]. Jack Benson, Wildlife Agent in Kodiak, in a March, 1941 letter to the Alaska Game Commission, detailed a proposal to move the Long Island deer herd to Afognak Island in anticipation of planned military fortification which, he felt, would doom the Long Island deer herd. The transplant was not initiated and deer were reduced to a low level when the Island was occupied by extensive military installations during the 1940s. Only an occasional straggler occupies Long Island today as cattle grazing, maturation of the spruce forest, and high recreational use of the Island have seriously diminished the habitat.

Back on Kodiak's mainland, the 1940s found deer rapidly occupying the northeastern corner of the Island. By 1950, deer were quite common near the town of Kodiak and the first hunting season was held in 1953. During that 5-day August season, 200 hunters took 38 bucks, mostly from the Chiniak Bay drainages. According to Chapados [1953], deer populations were still increasing on northeastern Kodiak in the early 1950s. While the nucleus of the population inhabited the Chiniak Peninsula and Chiniak Bay drainages, deer had already moved as far south and west as Ugak Bay, Terror Bay, and Uganik Island. Reports of deer on Whale, Raspberry, Afognak, and Shuyak Islands were becoming more common. Hoffman [1953] reported the first observation of deer wintering in the Pasagshak Bay area in 1953.

During the 1952-1953 winter, 11 deer were found dead of apparent malnutrition on the Chiniak Peninsula [Hoffman, 1953]. The same report stated that the browse on the winter ranges did not appear overutilized. The first season in 1953 followed the first reported significant mortality from winter starvation.

The remainder of the 1950s decade was marked by a rapidly increasing population spreading southward along Kodiak Island. In 1958, 25 percent of the harvest was taken in areas remote from the road system on northeastern Kodiak [Troyer, 1958]. By 1955, Troyer [1955] estimated that half the deer population was found outside the road system drainages. Although Troyer then opined that either-sex hunting would probably constitute good management, it wasn't until 1959 that a 3-day doe hunt was held. The annual harvest continued to increase as seasons became more liberal and deer populations expanded. The average annual harvest during the 1957-1959 period was about 200 bucks.

Whether by coincidence or consequence, the estimated Kodiak deer harvest nearly doubled when the State of Alaska assumed administration of its wildlife in 1960. A trend toward liberalization of harvest in the 1960s began when the bag limit was raised to 2 deer in 1960.

Bathelor [1962] observed that the major deer ranges occupied by the early 1960s were in the Sitka spruce climax forest of northeastern Kodiak and nearby islands. He observed that deer were found nearly exclusively in the spruce zone in bad weather. He felt that spruce cover was a primary requirement for establishing substantial deer populations, although acknowledging that Uganik Island, a relatively sparsely forested area, was already one of the major deer winter ranges.

Merriam [1964] reported that, by 1963, the deer population in the Chiniak Bay drainages had declined appreciably, despite a series of apparently mild winters and little observed mortality other than from hunting. In 1960, 41 percent of the harvest was recorded from the drainages along the road system between Kalsin and Women's Bays and this had declined to only 7 percent in 1962. Merriam felt that overhunting may have contributed to the decline and that areas without spruce forests were more likely to be overharvested. Erickson [1958] observed that competition between deer and cattle was occurring near the ocean fringe in the Chiniak Bay drainages. The lowlands near the ocean became critical range during periods of heavy snow cover. Erickson noted that willow (*Salix* spp.) and blueberry (*Vaccinium ovalifolium*), prime deer browse species, were also browsed heavily by cattle. He believed that cattle were primarily responsible for range deterioration. Recognizing that limited winter range was probably responsible in part for the decline, and observing that populations were building in other areas, Erickson recommended instituting an either-sex season encompassing the month of December, when deer would be vulnerable to hunting.

A record estimated harvest of 1,040 deer occurred in 1965 during a season extending from August through December 31. Over 400 deer (42 percent) were taken on the Chiniak Peninsula excluding the Kalsin Bay-Women's Bay drainages where the population had declined and had a more restrictive season. Another harvest record was set in 1967 when an estimated 1,500 deer were taken following a winter with only light natural mortality. The following year, the harvest rose to 2,100, with 50 percent of the harvest from the Chiniak Peninsula; the Chiniak Peninsula was probably at a population high then and has subsequently declined. The Chiniak Peninsula area today has the best deer population in the part of northeastern Kodiak Island accessible by road, but is still far below the mid-1960s level, despite relatively light hunting pressure. Much of the Chiniak Peninsula is only lightly grazed by cattle compared to the drainages in which the early-1960s decline was recorded. Extreme browsing of willow by deer is apparent along the ocean fringe wintering areas where cattle use is lighter or non-existent. Overall range quality has undoubtedly declined to well below the former carrying capacity.

During the 1969-1970 winters, unusually severe cold and heavy snows resulted in heavy mortality from starvation. Despite the low deer population, hunters took 870 and 915 deer following those respective winters. Although 54 percent of the harvest in 1971 came from the area accessible by road, hunters were taking deer on Afognak, Raspberry, Whale and Uganik Islands and about 10 percent of the harvest occurred even further south on Kodiak Island.

A general upward trend in the Game Management Unit 8 deer population has occurred since the 1970-1971 winter. During the past decade deer have populated most of the available deer habitat on Kodiak, Afognak and adjacent islands. Low densities of deer have inhabited even the tundra habitat of southwestern Kodiak Island. Reports of deer sightings in Deadman Bay, Olga Bay, Karluk Lake and Sturgeon River drainages have become more frequent in the past 5 years. Afognak Island, Raspberry Island, and

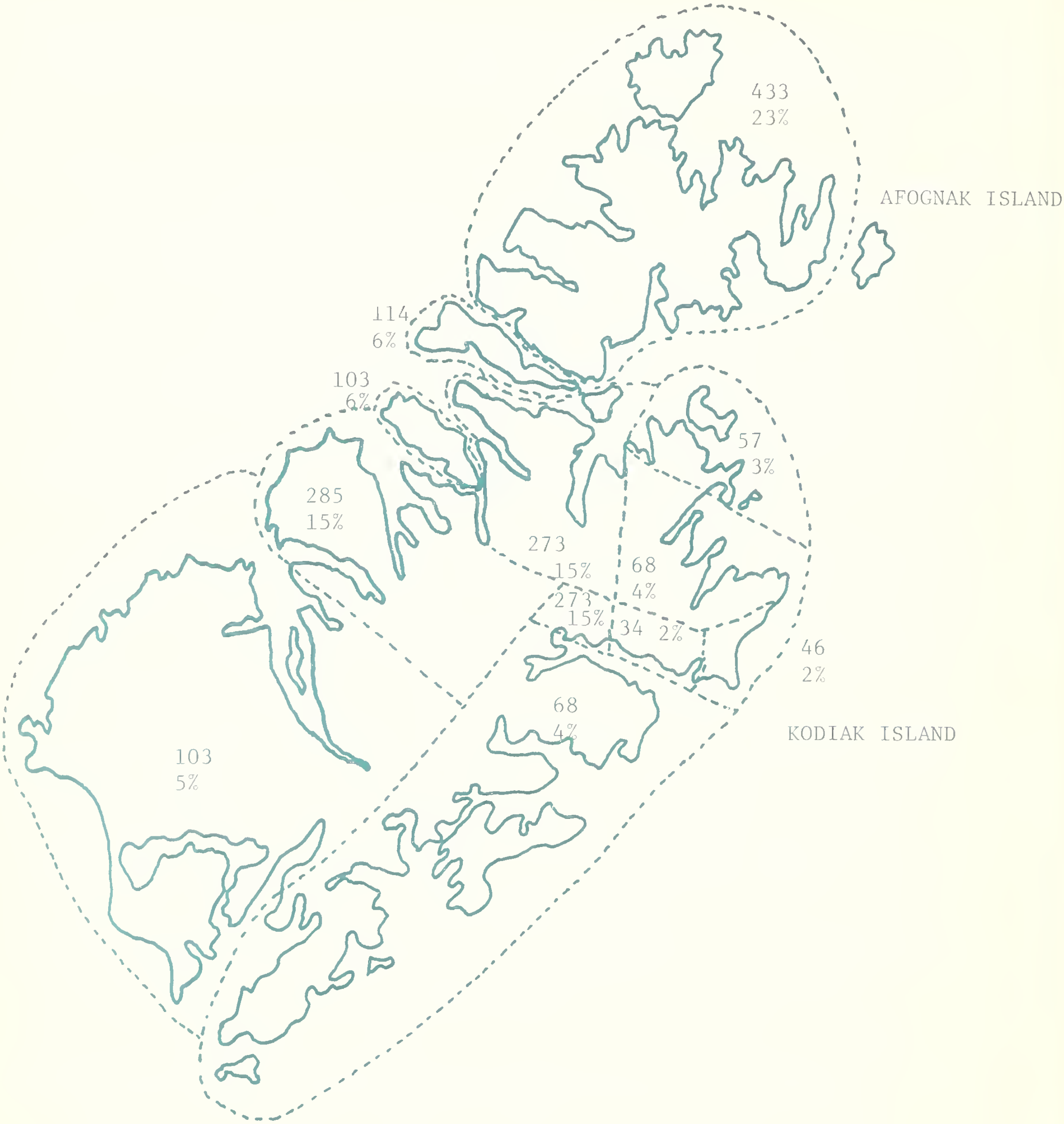

Figure 2. Distribution of 1977 deer harvest. Game Management Unit 8, Kodiak and adjacent islands.

Shuyak Island deer populations have increased steadily since 1971 and are probably at an all-time high.

Shifts in harvest patterns have followed the changes in distribution of high populations. In 1971 only 10 percent of the Unit 8 harvest was recorded from Afognak, Shuyak, and Raspberry Islands. During the 1975, 1976, and 1977 seasons, approximately 30 percent of the annual harvest came from these islands--an estimated 547 deer were taken on these islands in 1977, the largest take on record. Harvest has increased along the westernmost bays south of Uganik Island in the '70s, reaching a peak in 1976 with 34 percent (367 deer) of the Unit 8 harvest. Distribution of the 1977 estimated harvest is illustrated in fig. 2.

Deer habitat relationships and food habits--The diversity of habitats which now support deer populations belies the early predictions of Batchelor [1962] who believed spruce cover to be a requirement for establishing significant deer herds. The grass-brush vegetation type which covers most of Kodiak Island now supports higher densities of deer than any of the predominantly spruce habitat. Batchelor apparently felt that the grass-brush vegetation on most of Kodiak Island would not provide sufficient winter cover for deer. However, Batchelor underestimated the adaptability of the Sitka blacktail to non-coniferous habitat. The density of the cottonwood, birch and alder thickets is sufficient to provide considerable protection from the frequent storm winds and precipitation affecting the Kodiak area. Moreover, the diverse and relatively more abundant foods found in the grass-brush association appear to be capable of supporting more deer than spruce habitat, at least in the early years of occupation. During persistent deep snow conditions in this vegetation type, deer are susceptible to heavy winter losses as Batchelor predicted. However, observations indicate that the northern Kodiak and the Afognak Islands group frequently receive heavier and more persistent snowfall than the southern and western part of Kodiak Island. Deer in southwestern and central western Kodiak are less often subject to heavy snow conditions and, therefore, have increased chances for survival during most winters. Snow accumulations on Kodiak often do not exceed 1 to 2 feet on most of the deer winter ranges below 500 feet elevation. Rainy periods characteristically occur intermittently all winter, melting and crusting snow below 500-1,000 feet elevation. Deer sometimes range freely during the winter to above 1,000 feet into the edge of alpine areas which are normal summer and early fall ranges. The rain- and wind-crusted snow sometimes easily supports an adult deer when temperatures are below freezing. With warming temperatures and rain, snow becomes soft and may not support deer. Deer are sometimes seen moving freely over snow 3 or more feet in depth, foraging in willow and alder thickets and on wind-blown heath knolls at 800 to over 1,000 feet elevation. The advent of warming temperatures, rain or additional snowfall may cause deer to become entrapped at higher elevations where they subsequently starve. It is not unusual to find deer carcasses in such situations during winters with high snowfall. The occasional availability of these higher winter ranges is probably a positive survival factor.

Deer move into alpine ranges in late June, depending on snow-melt patterns and phenology. There is by no means a complete shift of deer populations to the alpine areas, as some deer are found at all elevations during summer. The alpine-subalpine range receives heavy use until mid-September when freezing weather desiccates herbaceous plants and occasional snowfall begins at higher elevations.

Evaluation of Kodiak's deer habitat is limited by scanty quantitative data on food habits and distribution and abundance of major food plants. Feeding observations, examination of browsed vegetation, and limited analysis of rumen contents provide some insight into deer food habits. Merriam [1964], in observing deer feeding in alpine and sub-alpine summer range, noted that fireweed (*Epilobium angustifolium*) was a primary summer food. Red-berried elder (*Sambucus racemosa*), Nootka rose (*Rosa nutkana*), salmonberry, cow parsnip (*Heracleum lanatum*), reedgrass, and hairgrass (*Deschampsia* sp.)

were fed upon to a lesser extent. Merriam [1968] noted that on Kodiak deer use many species of food plants not generally found or used on other Alaskan deer ranges. Rumen samples he examined, which were collected in November and December, contained substantial amounts of alder, spruce, willow, bearberry, crowberry, fireweed (*Epilobium angustifolium*) and various grasses. Spruce and alder are not preferred foods and use of these species probably indicates poor range condition or unavailability of forage due to snow cover.

Alexander [1968] used the point-frame method to analyze 49 deer rumen samples collected during December through March. Sampling rumen material from deer taken in both spruce and grass-brush habitat, he noted that diversity and probable nutritional quality of food species in non-spruce areas was much greater than in spruce areas. He found 12 species of plants in deer rumens from spruce habitat including cranberry, salmonberry, crowberry, fireweed, alder, spruce, kelp, lichens, and various grasses. He found 7 additional species used in the grass-brush areas, including highbush cranberry (*Viburnum edule*), bearberry, skunk cabbage (*Lysichiton americanum*), ground dogwood (*Cornus canadensis*), fern (*Dryopteris austriaca*) and birch. Alexander's study indicated that foraging on spruce increased as the winter progressed, as did use of kelp. Although spruce showed the highest frequency of occurrence and volume, red-berried elder and willow appeared to be the next most-heavily used plants in the spruce habitat. Crowberry, low cranberry, willow, salmonberry, Nootka rose, and red-berried elder appeared to be the most commonly used plants in non-spruce areas. The high use of kelp, alder, and spruce was evidence to Alexander that deer took foods of poor nutritional quality on spruce range.

Steep, windblown, and southerly-exposed hillsides are commonly used winter feeding areas. Deer forage on the rhizomes and petioles of the fern, *Athyrium filix-femina*, which is abundant on many sites. Hjeljord [1971] noted that this fern was the major food of mountain goats during 1 winter when he was studying food habits on Kodiak Island. The laterally-spreading form of the abundant alder intercepts snow, resulting in less accummulation under its stem, thereby facilitating goat feeding on the growing fern beneath, according to Hjeljord. I have observed deer feeding in similar sites, sometimes pawing through 12 to 18 inches of snow to feed on the fern. Hjeljord reported that the plant is rich in nitrogen-free extract.

The windblown capes and bluffs at the mouth of bays and along ocean entrances are favored wintering areas through the Kodiak Archipelago. Scattered heath patches are found near sea level in these areas and deer forage heavily on crowberry, low cranberry and bearberry. On some ranges these heath knolls are noticeably denuded by deer browsing. Cottonwood, birch, and scattered spruce pathces, dense alder thickets along steep draws provide cover.

Red-berried elder is one of the most heavily used browse species on most of Kodiak. The elder grows abundantly in association with the ubiquitous alder thickets. Deer strip the bark from the larger stems and take tops of the smaller stems. Highbush cranberry is a highly preferred species, often occurring as widely dispersed single plants. This species is severely browsed on northeastern Kodiak where deer have been present longest. The plant is much more abundant on the west side of Kodiak, often forming small thickets. A local resident reported that the cranberry crop in the Uganik Bay area noticeably declined after deer occupied the area. The plant may be a good indicator of the intensity of deer range utilization.

Afognak's deer undoubtedly use many of the same food plants used on Kodiak as the meadows and forest openings contain some of the same species. Blueberry is fairly abundant in spruce habitat and receives heaviest use under mature spruce forest adjacent to capes. Only light overall use of blueberry in the Afognak Island area is apparent, but deer populations have been low until recently and it may be a much more important browse species than is indicated. Afognak generally has deeper and more

persistent snow than most of Kodiak and deer do use beach timber fringes during severe winters. During many winters, however, rains and warmer temperatures prevent heavy snow accumulations. When heavy snows do occur, the coastal timber becomes critical for providing deer with cover and food.

Natural mortality--Overwinter mortality is assessed each spring by searching predetermined sections of coastal winter ranges much as Klein [1956] described for black-tailed deer in southeast Alaska. Deer are not forced onto the beaches in most of the grass-brush habitat of Kodiak, as occurs in the coastal forest areas of southeastern Alaska and Prince William Sound. Snow depths comparable to those of southeastern Alaska are seldom recorded on Kodiak. Deer generally range over a broader band of coastal winter range and frequently move up and down, elevationally, with changing snow conditions. While some deer may die close to the beach during heavy snow periods, others move away when rapid snowmelt occurs, subsequently dying some distance from the beach where they are less likely to be found during the spring searches.

The highest mortality recorded for Kodiak was 1.3 deer per mile after the severe 1970-1971 winter. The population was at a low then and much greater mortality probably would have been recorded with a higher population. Winter mortality on Kodiak, as indicated by searching beach transects, does not appear to be as extensive as in much of southeastern Alaska. Less severe winter conditions, wider elevational disperal of deer in winter ranges, and better quality winter range with a shorter history of occupation by deer may explain the relatively high survival of Kodiak's deer populations. With the lush herbaceous growth available on the summer range, deer may enter most winters with good fat reserves. It is not unusual to find significant backfat on mature bucks in late December, well after the rut. In northeastern Kodiak Island, with the longest history of occupancy by deer populations, some starvation losses occur during most winters, indicating that winter range is overutilized and much below its former carrying capacity. Some fawns are rather quickly lost to starvation when snow is deep enough to significantly hamper their movements.

Accidents account for minor losses of deer. Most occur during the winter when trails along cliffs become icy. Drowning accounts for a few deer who venture onto soft ice in lakes and protected bays or are injured and trapped by tides.

Predation and chasing by dogs accounts for an undertermined number of deer mortalities. Packs of free-roaming dogs are especially common near the town of Kodiak and other areas of human settlement. Deer frequently attempt to escape pursuit by swimming. Two adult deer were rescued from Women's Bay during the 1973-1974 winter after being chased by dogs. One was released, apparently in good condition after being dried and confined overnight. The other deer died of apparent exhaustion within a few minutes after rescue. Examination of femur marrow indicated that this deer, a buck estimated at 6 years of age, was in good condition. Another dead buck, cornered against a corral, showed severe hemorrhage from dog bites in the hindquarters but apparently died of exhaustion. Most deer-dog incidents occur when snowfall brings deer to low elevations.

Although brown bear sometimes feed on deer carcasses, there are no recorded incidents of brown bear predation on deer in the Kodiak area. Given the opportunistic nature of brown bear, predation on deer undoubtedly occurs, but is not a significant limiting factor on deer populations.

Management and harvest characteristics--An expanding deer herd and the remote location of some of the best deer populations dictate that management be directed toward achieving increased harvest. A 5-month season, beginning August 1 and ending December 31, and a 3-deer limit went into effect in 1963 over most of Kodiak and adjacent islands. In 1971, the bag limit was raised to 4 deer. The season was

extended through January 15 in 1978. Despite the liberal bag limit, long season, and either-sex hunting, harvest lags far behind being proportional to population increases.

Accessibility of hunting areas is the singlemost important factor determining hunting pressure. Many areas on eastern Afognak and western Kodiak Islands have high deer populations but are only lightly hunted. Float-equipped or amphibious aircraft and fishing boats are used almost exclusively to reach the more remote hunting areas. The presence of a large fishing fleet in Kodiak provides many boat owners and their friends an opportunity to hunt remote areas in relative luxury. The tempestuous nature of Kodiak's weather frequently postpones hunting trips by even the largest of the fleet, however. Trips to the west side of Kodiak, where deer populations are highest, involve passage through Shelikof Strait, one of the most notoriously hazardous stretches of water in Alaska. Some rather spectacular hunts are accomplished, as a single fishing boat may bring in 25 or more deer. Occasional complaints of excessive harvest are received when people observe large numbers of deer carcasses hanging from the rigging of boats as they return to the harbor. Although some of the large boat hunts take numerous deer, many are more of social than subsistence ventures. The characteristic cruising and searching until an animal is spotted is closely akin to "road hunting."

Approximately 50-60 percent of the estimated annual harvest is taken by hunters using boats for transportation. Probably half of this harvest is taken by hunters using small skiffs, but the type of boat used is not recorded in compiling harvest data. Small skiffs and cabin cruisers do provide transportation to many hunters residing in Kodiak and outlying villages. The southern coast of Afognak Island and Raspberry Island receive much of the hunting pressure by skiff hunters from Kodiak. Many skiff-borne hunters seek trophy bucks and go hunting nearly every suitable weekend during the season.

Approximately 20-30 percent of the annual harvest is taken by hunters using private or commercial aircraft for transportation. Less than 5 percent of the harvest is taken by hunters using their own aircraft. A few beaches are suitable for wheelplane operations, but amphibious and float-equipped charter aircraft provide most of the service to hunters. Floatplane use is limited to the more protected bays, lagoons and some lakes, prior to freeze-up. Many of the outer capes with high deer numbers also have rough seas which prohibit landings except on the rare calm days. Frequent windy, rainy, and foggy fall weather further limit the use of aircraft.

The cost of commercial aircraft transportation also limits its use by deer hunters, particularly for the more remote areas with high deer populations. A typical hunting party of 3 might spend $500-600 to charter a Grumman amphibian for a round trip to the better hunting areas.

The lack of good shelter discourages deer hunting to some extent. Approximately 2/3 of Kodiak Island is within the Kodiak National Wildlife Refuge which provides only a few public-use cabins in good deer hunting areas. There are numerous cabins on the Refuge which are under special use permits for salmon set-netting and these have been available to a limited extent for use by hunters prior to 1977. In 1977 the Refuge prohibited use of these cabins for activities other than salmon fishing. Some cabins on private lands are available to deer hunters when unoccupied. The U.S. Forest Service maintains a limited number of public-use cabins on Afognak, but all are not located in good hunting areas.

Although the hunting season begins in late summer, only about 10 percent of the annual harvest is taken during August and September when deer are frequenting alpine areas. Effort picks up in October as the dense vegetation dies back with the onset of freezing temperatures and occasional snows. Weather conditions largely determine the chronology of the harvest during the last 3 months of the year. It is not unusual for

a hunter to spend up to a week waiting in Kodiak for suitable flying or boating weather. Usually deer become more accessible later in the season as they move down into winter ranges. Sometimes significant snowfall does not occur during the season and deer remain widely dispersed.

During 1977, the estimated harvest, based on a telephone survey of 9 percent of the Kodiak hunting license purchasers, was 1,868 deer. This was the highest harvest since 1974, but represents a minimum estimate. Nine hundred fifty-seven hunters were estimated to have pursued deer. The telephone survey does not sample residents of outlying villages, hunters under 16 years old, hunters without licenses, or hunters who purchase licenses somewhere other than Kodiak. Analysis of 1975 harvest report returns indicated that 18 percent of the kill was taken by residents of other areas of Alaska. The harvest is probably at least 30 percent greater than that estimated from telephone hunter interviews. Using the 30 percent correction, the 1977 harvest was about 2,500 deer. Deer hunting pressure by residents of other areas of Alaska appears to be increasing with recent restrictions in seasons for moose and caribou.

Deer hunting in Unit 8 is both a recreational and food-gathering pursuit for most hunters. Although venison is highly valued for food, most hunters have either permanent or seasonal employment and are not dependent on deer for food. Some families with more than 1 hunter do, however, fill much of their red meat demand with venison. Some residents of outlying areas and villages hunt deer all year and probably depend fairly heavily on venison for food, thus freeing their cash for other needs. Approximately 75 percent of the hunters interviewed in 1977 took more than 1 deer, further indicating the desirability of venison for food. At 40 pounds of meat per deer and a harvest of 2,500 deer, the 1977 harvest represents 100,000 pounds of venison.

The fact that 60-70 percent of the deer reported taken are males indicates trophy selection is common. In the 1971 edition of Records of Alaska Big Game, 26 of 35 (74 percent) deer listed were killed on Kodiak. One Kodiak sport shop sponsors a highly popular "big buck" contest. It is rumored that a few local hunters far exceed the bag limit each year seeking large trophy antlers.

Summary and Conclusions

The inability to harvest Kodiak's deer populations at a level sufficient to affect their rapid growth is the major management problem. It is unlikely that enough hunting pressure will develop to exert controls on Unit 8 deer herds within the foreseeable future. Most of the available habitat is now occupied by deer, and high populations are present even in the most recently-occupied areas on western Kodiak and Afognak Islands. Deer numbers may be nearing an all-time peak in Unit 8. While much of the recently-occupied range on western Kodiak appears to offer better food plant diversity and abundance than found in northern Kodiak and Afognak, continued high populations will inevitably deplete the low coastal winter range. The population will then fluctuate with the severity of winters. A continuing series of mild, snow-free winters will accelerate the depletion of recently-occupied ranges. The decline of deer in northeastern Kodiak Island from early 1960s levels provides a good basis for this prediction.

Management will continue to be directed at maximizing harvest and recreational hunting opportunity. Even when deer populations are at low levels it is doubtful that hunting will become a limiting factor over most of the Kodiak area. The dense vegetation, severe weather and difficulty of access will enforce the law of diminishing returns.

In the most northeastern corner of Kodiak Island about 100 miles of roads provide relative easy accessibility. Continued closure of hunting during November and December, when deer move closer to the road system, should prevent overharvest. However, management emphasis there will be on providing maximum opportunity to hunt while minimizing harvest. Less than 10 percent of the annual harvest is taken there, although about half the hunters interviewed reported hunting 1 or more days in this area during the 1973 season. Illegal harvest and predation by dogs is potentially limiting when added to legal harvest. Competition with cattle for browse and increasing human settlement in this area will continue to diminish habitat.

Approximately half the coastline of Kodiak and Afognak Island will ultimately be deeded to Native village corporations under terms of the Alaska Native Claims Settlement Act. Some restrictions on access for hunting on these lands may be imposed, but will probably have little impact on deer hunting. Possible development of recreational cabins or other facilities may even benefit hunters. The impact of this change in land ownership on deer habitat will probably be minimal on Kodiak Island. Native corporations will receive title to much of the commercial forest lands in northeastern Kodiak, Afogank and adjacent forested islands. An accelerated logging program with extensive clearcuts could be detrimental to deer. Much of the area of the current U.S. Forest Service administered Perenosa Bay timber sale on Afognak will ultimately become Native corporation lands. Afognak has little previous history of logging and deer/habitat relationships are little researched. Additional research on plant succession in clearcuts, as well as seasonal food habits and habitat use by deer, is needed.

The introduction of Sitka black-tailed deer into the Kodiak Archipelago was one of the most successful transplants of big game animals done in Alaska. The full potential of recreational hunting for Kodiak's blacktails has yet to be realized. As hunting pressure increases in Alaska and keener competition for opportunity to hunt mainland species, such as moose and caribou, develops, more and more hunters will brave the vagaries of Kodiak's weather to pursue the mossy-backed blacktail.

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Evaluation of Methods Utilized to Estimate Deer Harvest in Alaska[1/]

by

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Introduction

From 1969 through 1974 personal hunter interviews and mandatory hunter report cards were used by personnel of the Alaska Department of Fish and Game to estimate the annual harvest of Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) in southeast Alaska.

The Department estimated annual deer harvests from 1959 through 1968 by hunter interview only. In 1969 the Department initiated a "mandatory" harvest report program for hunters of deer and several other big game species. The program consisted of the issuance of species tags to all hunters who were required by regulation to mail in results of their hunting effort. The program had many problems, one of which was that hunters were issued reports for species they did not intend to hunt. Beginning in 1971 individual deer harvest reports were issued. Both the deer harvest report program and the hunter interview were continued simultaneously in order to assure data continuity. Consequently, an opportunity was created to compare 2 independent methods for estimating annual harvest. The purpose of this paper is to document results obtained from each method, examine each method's benefits and shortcomings, and discuss their management implications and potential.

Numerous Department biologists provided assistance with the collection of data. Statistical advice and critical review were provided by Dr. Samuel Harbo, University of Alaska; M. Seibel, Alaska Department of Fish and Game, also provided statistical advice. Thanks are extended to R. Kramer, L. Johnson, R. Pegau, and S. Eide, Alaska Department of Fish and Game, for critically reviewing an earlier version of the manuscript. A. Cunning edited and typed several versions of the manuscript.

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Personal hunter interview--At the conclusion of each deer season, state personnel tabulated total numbers of resident license sales per town. Biologists or technicians then interviewed a 10 percent sample of hunting license holders in selected communities. Surveys were conducted where large numbers of interviewees were readily available, such as in post offices, government offices, or "on the street." Since 1959, the interviews were always conducted in 5 major southeast Alaska communities (Juneau, Ketchikan, Petersburg, Wrangell, and Sitka) and on occasion in smaller communities when time and manpower permitted.

Interviewees were selected by asking the question: "Did you purchase a hunting license this past year?" If the individuals answered "no" they were not interviewed further nor were they considered part of the sample. If they answered "yes," the following question was asked: "Did you hunt deer this past season?" If they answered "no," they were counted as a nonhunter. If they responded "yes," the interview was continued by asking the following questions:

(1) "How many days did you hunt and where did you hunt?"

(2) "Did you kill a deer?"

(3) If so, "What was the sex of the kill?" and

(4) "Where did you take it?"

At the conclusion of the interviews, area biologists computed percentages of active hunters, nonhunters, hunter success, deer per hunter, and days hunted per deer killed. These percentages were then directly applied to total license sales to estimate total number of hunters and total deer harvested by each community. Hunter interviews for southeast Alaska annually cost about $2,000 and required a minimum of 25 man-days of personnel time.

Mandatory harvest report cards--Prior to each deer hunting season, hunters were required by regulation to obtain harvest tickets which they were to punch immediately after harvesting a deer. Affixed to the punch card was a pre-addressed, stamped report card upon which each hunter was required to report hunt results and to mail the card in at the conclusion of the season.

Hunters were given 45 days after the conclusion of the season to send in their reports. At the end of the period, each nonreporting hunter was sent a reminder letter. Report holders were then given another 45 days to respond. At the conclusion of this time period, all returns on hand were keypunched and entered into a computer. Report cards or reminder letters received after this time period were not included.

Established computer programs summarized the harvest by specific location and game management unit. Estimates of total harvest and harvest per community were hand tabulated by applying the percent of respondents who hunted and deer harvested per hunter to total reports issued. Early computer-based analyses were not conducted on a community basis and so data were hand tabulated by utilizing zip codes of responding hunters; thus, some recording errors were possible. About 2 percent of the harvest data were not identifiable to individual communities. These data were used in this analysis, however, by assuming that the percentages of identifiable community data also applied to the data of unidentifiable origin. The harvest report system for southeast Alaska annually costs the Department approximately $12,000 and requires about 50 man-days of personnel time.

Comparisons of total annual deer harvest estimates, based on reports versus interviews for 1969 through 1974, indicated that both estimates provided the same annual trend for total deer harvest (fig. 1). However, the hunter interview estimates were considerably higher than the harvest report figures. Differences range from a 68 percent higher estimate in 1969 to a 9 percent higher estimate in 1972. Overall for the study period, the interview provided a 38 percent higher estimate of deer kill.

Comparisons by community of annual southeast Alaska deer harvest statistics for 1969 through 1974 revealed that, for individual communities, the hunter interview estimates of various statistics were higher than those provided by harvest reports (table 1). The only exception occurred for actual deer kills reported by respondents on both survey methods. This exception was expected, since the deer harvest report was an attempt at total enumeration whereas the interview was a 10-percent sample of licensed hunters. Deer harvest report response rates during the study period averaged 71 percent, excluding 1973 when reminder letters were not sent.

The relationship between estimates of annual deer harvested per community, as derived from the 2 survey methods, was assessed with a correlation analysis. The 2 estimates were significantly correlated ($r = 0.92$, $\underline{P} < 0.01$), with interview estimates being considerably higher than those of the harvest report. The magnitude of the differences between the 2 methods appeared greater for the larger communities sampled.

Numbers of total hunters per community as estimated from the 2 methods were compared. A significant correlation ($r = 0.88$, $\underline{P} < 0.01$) existed, with the hunter interview providing the larger estimate. Differences between the 2 estimates did not appear to be related to size of communities sampled. A Chi-square analysis of annual reporting successful to unsuccessful hunters per town for each method was performed in an attempt to determine whether each method was sampling the same hunter population. Significant differences ($\underline{P} < 0.01$) were detected for Ketchikan-1970, Petersburg-1970, Wrangell-1970, and Sitka-1974. Differences in 1970 are believed due to the use of an untrained interviewer. No explanation can be given for the difference in the Sitka-1974 data. All other ratios were not significantly different ($\underline{P} > 0.01$), indicating that both methods were sampling from the same hunter population.

Numbers of hunting licenses sold and harvest reports issued per community for 1973 and 1974 were significantly correlated ($r = 0.9$, $\underline{P} < 0.01$). Number of hunting licenses sold was higher than number of harvest reports issued per community. These data are of significance because they provide the basis for projecting total numbers of hunters and total estimated deer harvest. If each method had provided a similar deer-harvest-per-hunter value, the interview estimates would be higher due to the baseline data from which the estimate is calculated.

Estimated harvests per hunter per community as derived from each method were significantly correlated ($r = 0.87$, $\underline{P} < 0.01$). The hunter interview estimates of deer harvested per hunter had a significantly higher variance ($F = 2.3$, 19 df, $\underline{P} < 0.05$) than the harvest report estimates. Since the data collected on deer harvest from 1969 through 1973 indicated a considerable discrepancy between the 2 methods, an effort was made during the 1974 interview to acquire the name of each hunter interviewed so that individual report responses could be compared. Hunters were asked their name after the interview was concluded.

Data from hunters interviewed were divided into: (a) report holders who stated they hunted and (b) those who stated they had not hunted. Four hundred and twelve individuals were interviewed for the 1974 hunting season, of which 223 (54 percent) responded that they had hunted. Of the reported hunters, 203 (91 percent) had

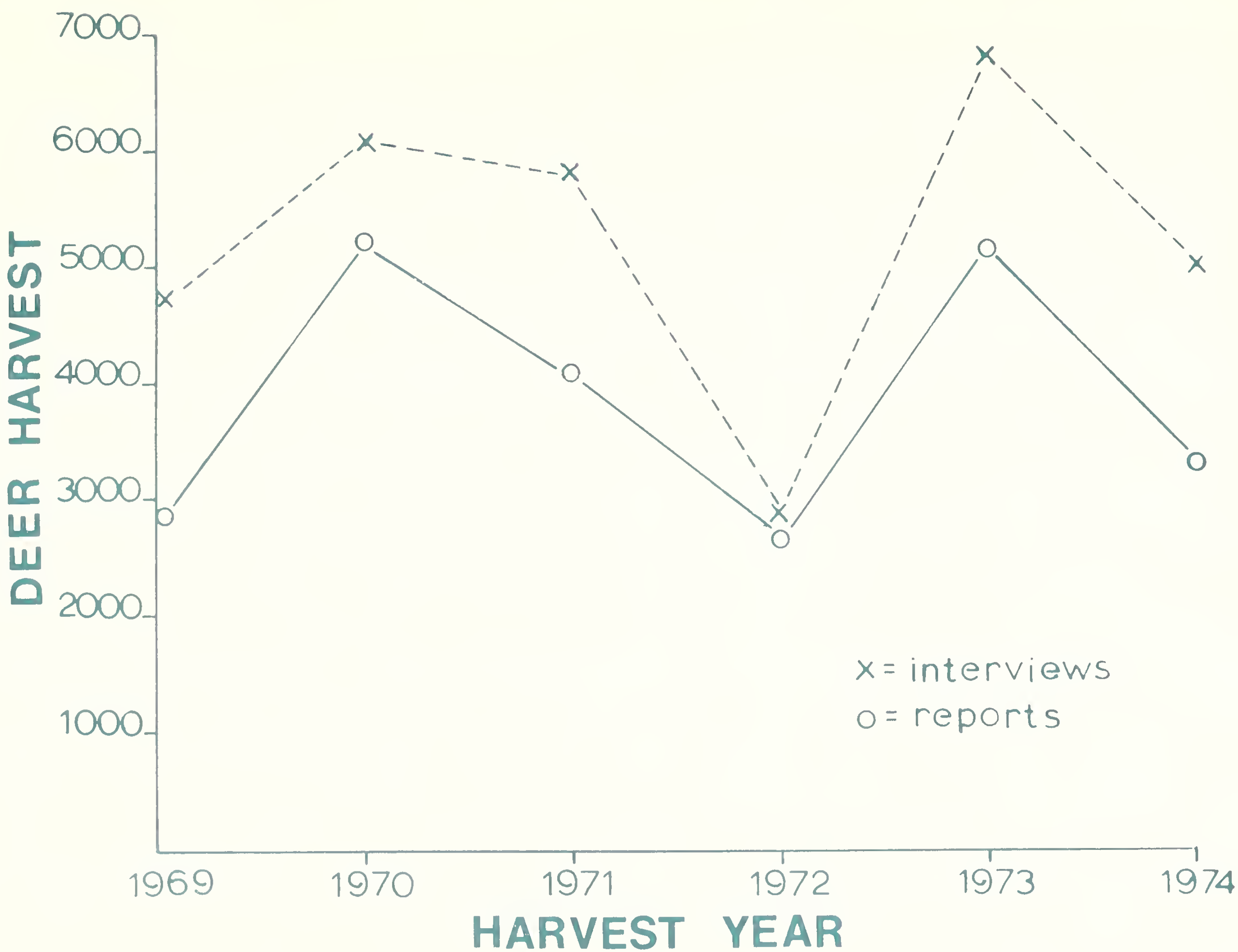

Figure 1. Estimated annual southeast Alaska deer harvest derived from interviews versus reports, 1969 through 1974.

Table 1. Comparison of deer harvest statistics as obtained from 2 survey methods [interview (Int.) and report (Rep.)] for selected southeast Alaska communities, 1969 through 1974.

Year	License sales	Harvest reports issued	Percent doe harvest		Percent who hunted		Estimated number of hunters		Estimated deer per hunter		Estimated total deer harvest	
			Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.
Juneau												
1969[b]	2,580	a	56	a	66	a	1700	1279	.61	.42	1037	537
1970	3,120		49		54		1680	992	1.20	.92	2016	913
1971[c]	3,286		49		62		2037	1296	.90	.78	1833	1011
1972	3,253		47		51		1659	1215	.50	.53	830	644
1973[d]	4,053	2,689	48.3	48.7	58.4	66.0	2367	1771	.77	.98	1823	1735
1974	3,687	2,586	40.7	36.3	53.4	63.1	1969	1627	.61	.61	1201	993
Ketchikan												
1969[b]	2,060	a	36	a	78	a	1610	1326	1.21	.66	1948	875
1970	2,160		35		74		1600	1178	1.10	.93	1760	1096
1971[c]	2,216		28		74		1640	1180	.70	.66	1148	779
1972	1,912		44		64		1224	814	.40	.34	490	277
1973	2,245	1,593	27.6	28.5	76.0	72.2	1706	1149	.64	.62	1092	712
1974	2,089	1,488	42.9	23.9	69.0	64.9	1437	963	.36	.38	517	366
Petersburg												
1969[b]	780	a	43	a	79	a	620	575	.51	.52	316	273
1970	820		27		70		570	484	1.39	.61	792	295
1971[c]	794		35		75		596	427	.85	.90	507	384
1972	666		33		66		440	266	.30	.50	132	133
1973[d]	788	453	48.1	40.7	57.5	53.9	453	244	1.13	1.11	512	201
1974	709	445	44.7	29.7	53.8	46.3	381	205	.88	.85	335	174

Continued

Table 1. (continued)

Year	License sales	Harvest reports issued	Percent doe harvest		Percent who hunted		Estimated number of hunters		Estimated deer per hunter		Estimated total deer harvest	
			Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.
Sitka												
1969[b]	810	a	52	a	75	a	610	743	.80	.60	490	446
1970	1,080		42		76		820	812	2.10	1.31	1720	1064
1971[c]	1,025		48		81		830	824	1.70	1.33	1411	1096
1972	879		45		86		756	761	1.40	1.19	1058	906
1973[d]	1,297	1,060	42.7	31.3	83.1	81.4	1091	867	2.45	1.76	2673	1526
1974	1,265	1,119	44.4	33.5	84.6	79.3	1070	831	1.91	1.43	2044	1188
Wrangell												
1969[b]	500	a	44	a	86	a	430	378	.59	.48	254	181
1970	500		64		70		350	381	.40	.95	140	362
1971[c]	592		25		55		326	242	.39	.40	127	97
1972	558		45		53		296	171	.31	.35	92	60
1973[d]	655	446	33.3	00.0	35.0	43.6	229	194	.57	.27	131	52
1974	581	485	33.3	24.4	46.0	43.5	267	211	.62	.30	116	63
Other[e]												
1969[b]	590	a		a		a	470	713	1.52	.72	700	513
1970	590						389	1005	1.34	1.46	521	1467
1971[c]	603						513	710	1.50	1.00	770	710
1972	739						473	644	.60	.97	284	625
1973[d]	830	1,063			63.4		516	664	1.11	1.31	573	870
1974	1,602	1,102			53.0		953	581	.82	.95	781	552

Continued

Table 1. (continued)

Year	License sales	Harvest reports issued	Percent doe harvest		Percent who hunted		Estimated number of hunters		Estimated deer per hunter		Estimated total deer harvest	
			Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.	Int.	Rep.
Totals												
1969[b]	7,320	a	a	a	a	a	5440	4964	a	a	4745	2825
1970	8,270						5409	4852			6019	5197
1971[c]	8,516						5942	4679			5796	4077
1972	8,007						4848	3871			2886	2645
1973[d]	9,867	7,310					6362	4889			6804	5166
1974	9,933	7,225					6077	4418			4994	3336

a - Data by community for 1969 through 1972 not available due to computer programming difficulties.
b - Multi-species tickets initiated.
c - Single-species tickets initiated.
d - No reminder letters were went.
e - Hunter interviews were not conducted in other communities, harvest estimates calculated by using averages of major communities.

possessed harvest reports. Of those that had possessed reports, only 159 (78 percent) returned them. Overall, this gave the harvest reports a 71-percent sample of actual hunters, assuming the interview data were accurate. One hundred eighty-nine individuals were interviewed who stated they had not hunted. Of that figure, 83 (44 percent) had possessed harvest reports with 66 (80 percent) of these individuals having returned them. Ten of the interviewed individuals, who stated they had not hunted, reported on the harvest report card as having hunted.

It was apparent that the successful hunters who did not possess harvest reports, and those who did but failed to return them, accounted for some of the discrepancies between the 2 methods. According to these data, about 9 percent of the successful hunters interviewed may not have possessed reports while 29 percent of the successful hunters who did possess them failed to return them. These 2 groups combined account for 28 percent of the reported deer harvest, according to interviews. Conversely, 8 percent of the successful hunters who sent in their reports stated during the interviews that they had not hunted deer. Their reported kills account for 6 percent of the total harvest according to the reports.

Individual responses of hunters who participated on both surveys during 1974 were compared. No significant differences were detected for total deer harvested ($t = 0.01$, 63 df, $\underline{P} > 0.05$), total doe harvest ($t = 0.22$, 63 df, $\underline{P} > 0.05$), or total days hunted

($t = 0.08$, 97 df, $P > 0.05$). These data indicate that when hunters did respond on each survey method they provided similar data.

Mean days hunted per deer harvested from 1971 through 1974 as derived from each method were significantly correlated ($r = 0.82$, $P < 0.01$). Percent doe harvest percentages for 1973 and 1974 were not significantly correlated ($r = 0.45$, $P > 0.01$). The data indicate that interviewed hunters report a higher percent doe harvest than that provided on reports.

There was a significant correlation ($r = 0.91$, $P < 0.01$) between the percentage of interviewees and the percentage of harvest report respondents who reported hunting in 1973 and 1974. These data indicate that each method may provide an adequate representation of the percentage of the potential hunter population that actually hunted for deer.

Discussion

Traditionally the 3 basic methods of determining big game kill have been check station records, hunter report cards and random sampling, either by mail or personal interview [Hunter and Yeager, 1949]. Mandatory harvest reports have been used by many conservation agencies at one time or another; in recent times most have changed over to a random mail survey [Eberhardt, 1969]. A few states have used personal interviews [Hunter, 1949]; however, due to increasing numbers of hunters and a need for more accurate figures this method has been found unsuitable.

Data provided by this study indicate that both the harvest report and hunter interview provide the same annual trends for total deer harvest in southeast Alaska. The hunter interview estimates were, on the average, 38 percent higher than those provided by the harvest report. Differences between the results acquired from the 2 methods may have been due to a combination of the following: issuance of multi-species tags in 1969 and 1970, initially poor acceptance of the report program by the hunting public, use of different baseline data, poor organization of computer programs, non-randomness of interviews, and non-compliance with report program, and probably a large number of biases associated with each method. In addition, since both estimates were hand tabulated, some recording errors were possible. Report data provided since 1972 appear to be more accurate and there appears to be a greater public acceptance of the program.

The hunter interview was intended to provide a random sample of hunters from each community; however, there appears to be a considerable amount of difference between communities in the way the interview was conducted. Interviews conducted in such places as post offices, grocery stores, state office buildings, and "on the street" are not random and thus could consistently result in a non-representative sample. Furthermore, there was a tendency for interviewers to avoid female and juvenile hunters.

McDonald and Dillman [1968] conducted a 3-year survey of response and nonresponse biases associated with random sample surveys by means of mail questionnaires. Their studies indicated that there were prestige biases involved. That is, some individuals who report not killing actually did kill. These same types of biases appear to be present in both of the methods compared in this study. The exact extent of the bias, however, will remain unknown since there is currently no feasible way to accurately determine actual kill in southeast Alaska.

Comparison of the harvest report to the interview indicates that a portion of the hunters sampled in the interview did not possess harvest tickets (9 percent). Of those that did possess tickets, 20 percent did not return them. The 2 groups combined accounted for 28 percent of the deer harvest as reported on the interview. These figures alone could indicate that the hunter interview is providing more reliable data than that derived from the reports; however, this is based on the assumptions that all hunters were reporting their harvest correctly and that the interviews were random. There is reason to believe that both assumptions may be incorrect. A number of studies have indicated tendencies for some hunters to falsely report the number and sex of their kill [Eberhardt and Murray, 1960; Menzel, 1968]. In Alaska, Johnson (*in* McKnight, 1974] has reported that harvests well in excess of the bag limit are sometimes common in communities where "subsistence use" is high. If this is correct, then it is quite conceivable that harvest estimates derived from either method are incorrect. If bag limits are sometimes exceeded then hunt information as to sex, location, and date of kill would vary depending on which animals the hunter decided to report. Also, if interviewed hunters were reporting accurately, but the sample was not representative, considerably discrepancies could occur.

It was noted that the hunter interview contained more variation in many of the harvest statistics than did the harvest report. Reasons for the variability are not known, although factors such as differences in interviewer and interviewee personality, small sample size, exclusion of most female and juvenile hunters, procedures for conducting interviews, and interview locations could add a considerable amount of unmeasurable variation and thus provide a nonrepresentative sample. Some of the obvious advantages and disadvantages of each method are listed below.

Hunter interview - advantages:

1. Cost is considerably lower than harvest reports.

2. Data are available within short period after conclusion of season.

3. Some public relations value is obtained.

Hunter interview - disadvantages:

1. Contains a considerable number of unmeasurable variables.

2. Sample size is proportional to manpower and funds available and thus many communities are not sampled.

3. Both out-of-state and nonlocal hunters are not sampled.

4. Samples often exclude juvenile and female hunters.

Harvest report - advantages:

1. A great volume of data on individual hunters and hunt areas is available.

2. Some of the variables associated with method are measurable.

3. All communities and hunter classes are sampled.

4. Data are analyzed and logged in uniform systematic manner for documentation purposes.

Harvest report - disadvantages:

1. Cost is considerably higher than interview.

2. Computer printouts are not available until 3 to 4 months after conclusion of season.

3. An unknown percentage of hunters may not participate in program.

4. Does not measure harvest in excess of legal bag limit.

For management purposes the most significant finding of this study is that both methods provide the same annual trend for total harvest. Deer management by the Department has consisted of occasionally altering seasons and bag limits, most of which have been due to public demand rather than biological reasons [Merriam, *in* McKnight, 1971]. He believes that sport hunting is not now a regulating factor on deer populations and, therefore, no severe adjustments in season lengths or bag limits are necessary. If this situation were to continue, the need for accurate harvest data would be unnecessary. Therefore, either of the 2 methods would be satisfactory for most management purposes under those circumstances. However, if hunting pressure increases as it has elsewhere and if land management agencies continue to request hunt information by specific areas then hunter interviews will be inadequate.

Arney [1975] reviewed the methods utilized for estimating harvests in 13 western states and summarized problems associated with each method. He found that 5 of 13 states used the interview methods but "practically all" were one-shot special studies. Whereas 8 of 13 utilized the report method because it had higher public acceptance and a low cost per response. Reports, however, were plagued with low return rates, non-return bias and reporting bias. Although these latter problems can be solved with special studies, the correction factors change with time and return rates [Arney, 1975]. Consequently, to provide accurate harvest statistics, effort should be periodically addressed to measuring the biases associated with the reports or a new system, such as random mail questionnaires, should be investigated for its suitability under Alaskan conditions.

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Deer Pellet Deterioration

by

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Introduction

The only currently feasible method of estimating relative deer population densities in southeast Alaska is the pellet-group-count. The application of the pellet-group-count method depends in part upon the rate of deterioration and/or disappearance of pellets. In an effort to determine factors affecting decomposition rates, a study involving a small number of fresh, spring pellet groups was initiated.

Study Area and Methods

In mid-May 1977, 15 fresh pellet groups were collected in the field at Young Bay and transferred to the lower Fish Creek area on Douglas Island. is area provided convenient access from Juneau and was close to a permanent Nation.. Weather Station.

Twenty pellets from 12 groups were redeposited on 12 plots in each of 2 sites chosen to represent the most common situations in which pellet groups could be expected to occur. On each of the 12 plots, the 20 pellets were distributed more or less equally spaced within a 0.3-meter-diameter circle. From the remaining 3 groups, 20 pellets each were placed at each site on 3 each 0.3-meter squares of burlap staked to the ground for photographic records described later.

Of the sites selected, 1 was an open muskeg containing 10 percent or less tree/shrub canopy. Ground cover consisted of sparse vaccinium (*Vaccinium* sp.), bunchberry (*Cornus canadensis*), sparse sedge (*Carex* sp.), and very dense sphagnum moss (*Sphagnum* sp.). The second site (50 percent or more tree/shrub canopy) was approximately 100 meters distant within a 100-year-old hemlock-spruce forest with 80 percent overstory. Ground cover included large vaccinium, bunchberry, several other forbs, very dense feather moss (*Hylocomium* sp.) and leaf-needle litter. Both sites were approximately 75 meters in elevation.

The plots were checked every 4 to 6 weeks from May through October 1977. At these intervals, each sample plot was searched and all visible pellets (some present but hidden by vegetation) within the 0.3-meter circular plot were counted. A vertical photograph of the plot was taken from a height sufficient to allow the circular plot to essentially fill the frame. Low-speed color film was used to produce 3-1/2 x 5-inch prints, with the time exposure and flashbulb release for constant light conditions. A closeup photograph was also taken of the pellets on the burlap.

Mapping and interpretation was done directly from the 3-1/2 x 5-inch color prints. Some detail was lost in the preparation of the prints, but image quality was quite satisfactory and color rendition and contrast were good. Several photos contained shadows or were very dark making it impossible to locate some pellets. This may have been because of a malfunction or misuse of the flash unit.

Local precipitation and temperature data were obtained from monthly summaries of the National Weather Service, International Airport, Juneau, located approximately 1.6 kilometers each of the study site.

Results

Weather records--Monthly precipitation totals for the months of May to October fall within the recorded extremes for these months back to 1950 (fig. 1). The May total of 3.96 centimeters, though, ran a close second to the low recording of 3.68 centimeters in May of 1968. Mean monthly temperatures, except for August, also fell within the recorded extremes from 1950. August set a 27-year record with 1.6° C above the high of 14.2° C recorded in August of 1957 (fig. 2).

From May to October only 2 rainfalls occurred that could be considered as high intensity or washing rains--high intensity arbitrarily being 1 inch (2.54 centimeters) or more within a 24-hour period. These heavy rains occurred on June 2 with 2.59 centimeters and September 21 with 3.25 centimeters. Although only 2 heavy rains fell during the study, weather records show that high intensity rains can occur in any month of the year, but occur more frequently in the later summer months. In the Juneau area at least, rainstorms of high intensity normally can be expected frequently in the period of August to October.

From May 12 through October 20 (162 days), it rained a trace or more on 102 days, for a total of 63 percent of the days (table 1). Although it did not rain constantly for 24 hours during the 102 days, it is assumed that enough rain fell to keep ground, vegetation, and pellet moisture contents relatively high.

Pellet decomposition and disappearance--

Forest canopy. Of the 240 pellets deposited on plots within the forest canopy, 179 (75 percent) had completely disappeared within 6 months (table 2). Remaining pellets ranged from 10 (50 percent) to 1 (5 percent) per plot. Many pellets visibly disappeared into the 2- to 5-centimeter-deep feather moss as soon as they were deposited; others gradually disappeared as new vegetation progressed. They became increasingly more difficult to locate with each successive observation period. By mid-August, ground vegetation became dense enough that most pellets on plots were impossible to see and photograph (table 3) (fig. 3) and only pellets on the burlap remained visible.

Figure 1. Monthly precipitation at Juneau Airport 1977 and 27 year range

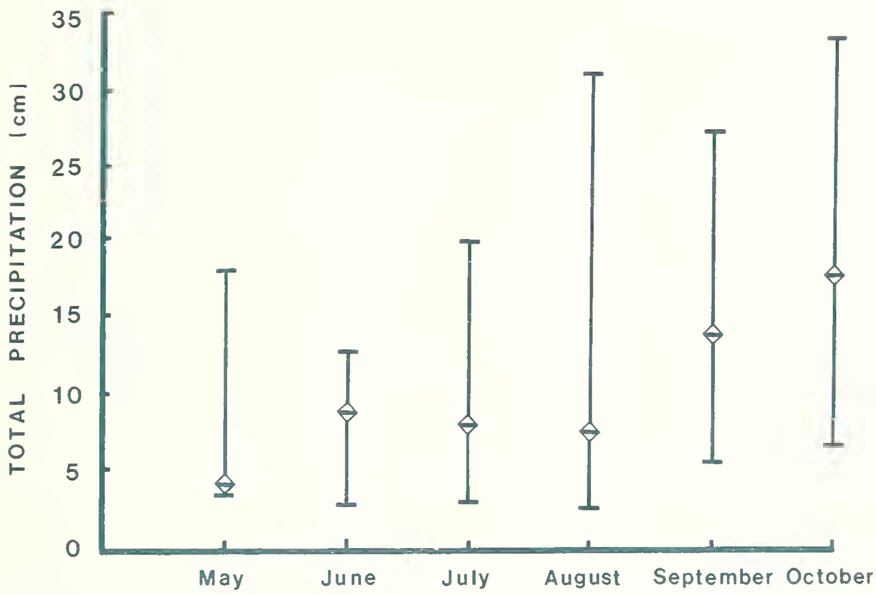


Figure 2. Mean monthly temperature at Juneau Airport 1977 and 27 year range

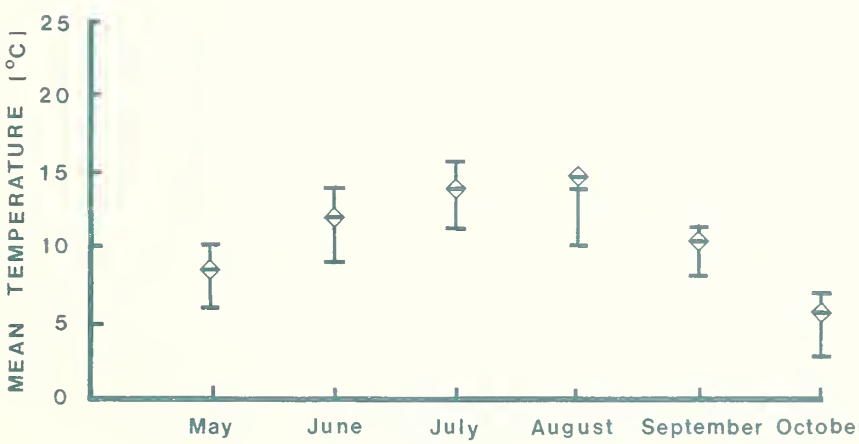


Table 1. Summer precipitation recorded at Juneau Airport, 1977.

Month	Days	Days rained	Total rainfall	Long-term mean
			------centimeters-------	
May (12-31)	20	11	3.15	5.39
June	30	22	8.81	7.44
July	31	18	8.10	11.91
August	31	14	7.70	12.70
September	30	21	14.15	16.74
October (1-20)	20	16	12.42	14.22
Total	162	102	54.33	68.40

Table 2. Pellets per plot on successive observation dates

Plot	May 12	June 8	July 12	Aug. 12	Sept. 17	Oct. 20
			Muskeg			
1a	20	20	19	20	20	20
2a	20	20	18	19	19	17
3a	20	20	20	20	20	18
4a	20	20	20	20	20	18
5a	20	16	10	10	10	10
6a	20	20	19	19	19	18
7a	20	20	20	20	20	20
8a	20	20	20	20	20	20
9a	20	20	19	19	19	18
10a	20	19	18	17	17	15
11a	20	20	20	19	19	18
12a	20	20	20	20	20	15
Total	240	235	224	223	223	207
Mean/plot	20.0	19.6	18.7	18.6	18.6	17.3
			Forest			
1b	20	16	11	12	11	$\underline{3}$[1/]
2b	20	14	12	$\underline{7}$	$\underline{6}$	$\underline{2}$
3b	20	20	16	13	12	$\underline{5}$
4b	20	15	14	$\underline{6}$	$\underline{5}$	$\underline{1}$
5b	20	17	16	16	10	$\underline{8}$
6b	20	16	12	11	11	$\underline{5}$
7b	20	20	15	11	$\underline{9}$	$\underline{4}$
8b	20	17	15	10	$\underline{9}$	$\underline{5}$
9b	20	14	13	15	12	$\underline{7}$
10b	20	20	15	12	12	$\underline{8}$
11b	20	12	$\underline{6}$	$\underline{6}$	$\underline{5}$	$\underline{3}$
12b	20	20	16	14	13	10
Total	240	201	161	133	115	61
Mean/plot	20.0	16.7	13.4	11.1	9.6	5.1

1/ Underscore indicates that the pellet group was essentially indistinguishable.

Table 3. Presence of visible groups on plots on successive observation dates

Plot	May 12	June 8	July 12	Aug. 12	Sept. 17	Oct. 20
	----------	----------	----------	-Muskeg-	----------	----------
1a	x	x	x	x	x	x
2a	x	x	x	x	x	x
3a	x	x	x	x	x	x
4a	x	x	x	x	x	x
5a	x	x	x	x	x	x
6a	x	x	x	x	x	x
7a	x	x	x	x	x	x
8a	x	x	x	x	x	x
9a	x	x	x	x	x	x
10a	x	x	x	x	x	x
11a	x	x	x	x	x	x
12a	x	x	x	x	x	x
Total	12	12	12	12	12	12
	----------	----------	----------	-Forest-	----------	----------
1b	x	x	x	1/		
2b	x	x	x			
3b	x	x	x	x		
4b	x	x	x	x		
5b	x	x	x	x		x
6b	x	x	x			
7b	x	x	x	x		
8b	x	x				
9b	x					
10b	x					
11b	x					
12b	x	x	x	x		
Total	12	9	8	5	0	1

1/ Blank indicates that the pellet group was not visible.

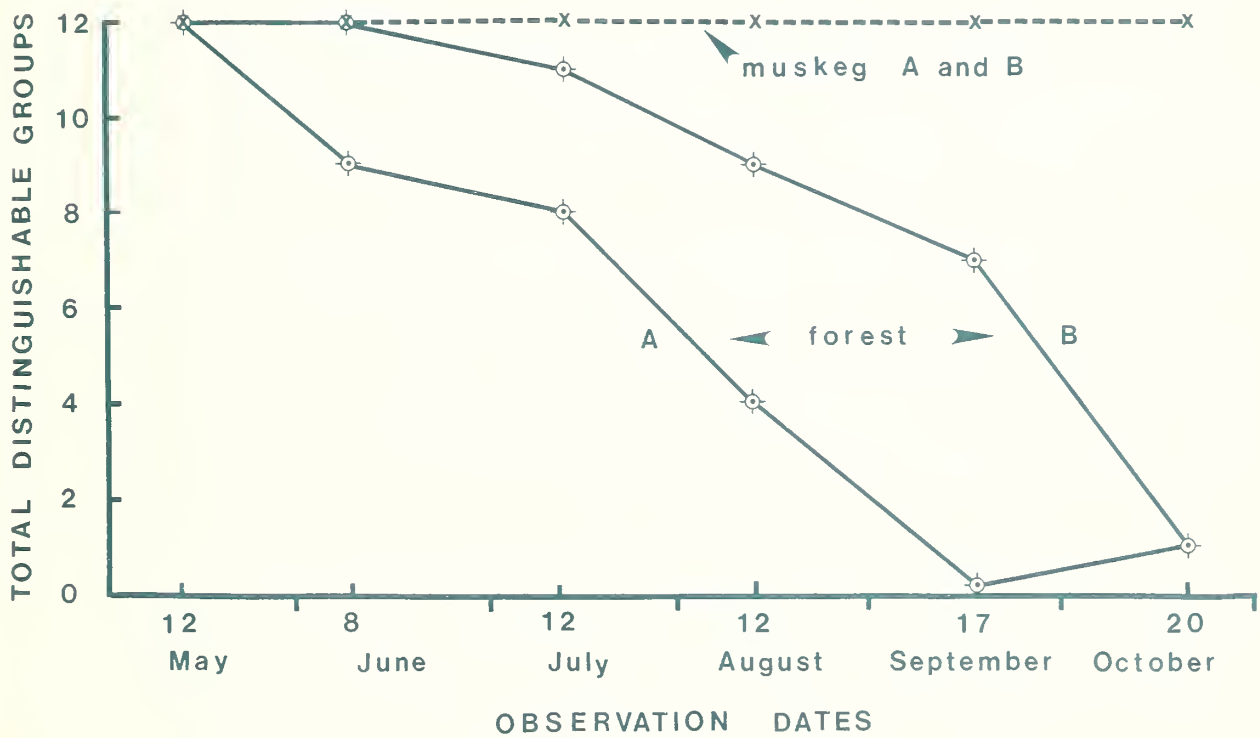


Figure 3. Disappearance rate of individual pellet groups in forest and musket. Visible (A) and searched (B)

The pellets remained dark grey to black in color and pliable and soft, due no doubt to the persistent moisture conditions within the forest vegetation. This is in direct contrast with drier areas where pellets become firm and fade to lighter brownish colors. The deposited pellets did not retain their original shape or size but became flatter and smaller, and texture gradually turned grainy.

Under the forest canopy, pellets on the burlap retained the same color, changed size and shape, and turned grainy similar to those in the moss. They did, however, appear firmer due possibly to the drier burlap substratum and air currents.

Beetle activity was noted on 3 occasions but only early in the season. They appeared to be utilizing the pellets from the inside so many more beetles may have been present but not noticed. Further study is needed of numbers of pellets beetles actually consume and at what part of the season they are most active.

Muskeg. Of pellet groups placed on the open muskeg, 50 percent or more remained intact and identifiable even after 6 months (table 2); 3 plots still contained the original 20 pellets. One had been reduced to 10 pellets before the July investigation--no evidence of decay or disappearance was found, suggesting an unidentified source of removal, possibly rodents or beetles. By mid-October, 207 of the original 240 pellets could still be counted for a loss of only 14 percent (fig. 4). As for distinguishable groups, all 12 (100 percent) could still be considered as such after 6 months (fig. 3).

On the muskeg site, vegetation became greener, but remained shorter and less dense, than on the forest site. Surviving pellets continued to be identifiable and easily counted and photographed. The pellets changed through a series of colors from black, to a variety of greys, and finally a bleached, washed-out appearance. They remained firm to the touch and appeared to be smaller in size than pellets in the forest. They, too, gradually became more grainy. Beetle activity was noted in 3 instances early in the study. Pellets on the burlap changed in color, shape, and texture similar to those on the vegetation.

As shown in figures 5 and 6, individual pellets disappeared or changed location from 1 observation to the next. I did not determine causes of movement, but vegetation, intense rainfall, wind, insect, or animal activity are speculative causes.

Unfortunately, this information cannot be considered applicable to all ecological situations. This paper considers the results from only 1 study area in southeast Alaska and represents only 2 ecological conditions. Any definite conclusions will probably require observations of marked pellet groups over several years.

Further Research Requirements

Future research on rates of pellet decomposition relative to the pellet-group-count method should be directed at continuing to identify the major factors influencing these rates, not only for spring-summer pellets, but fall-winter pellets. A study similar to the summer test is currently in progress using winter-deposited pellet groups.

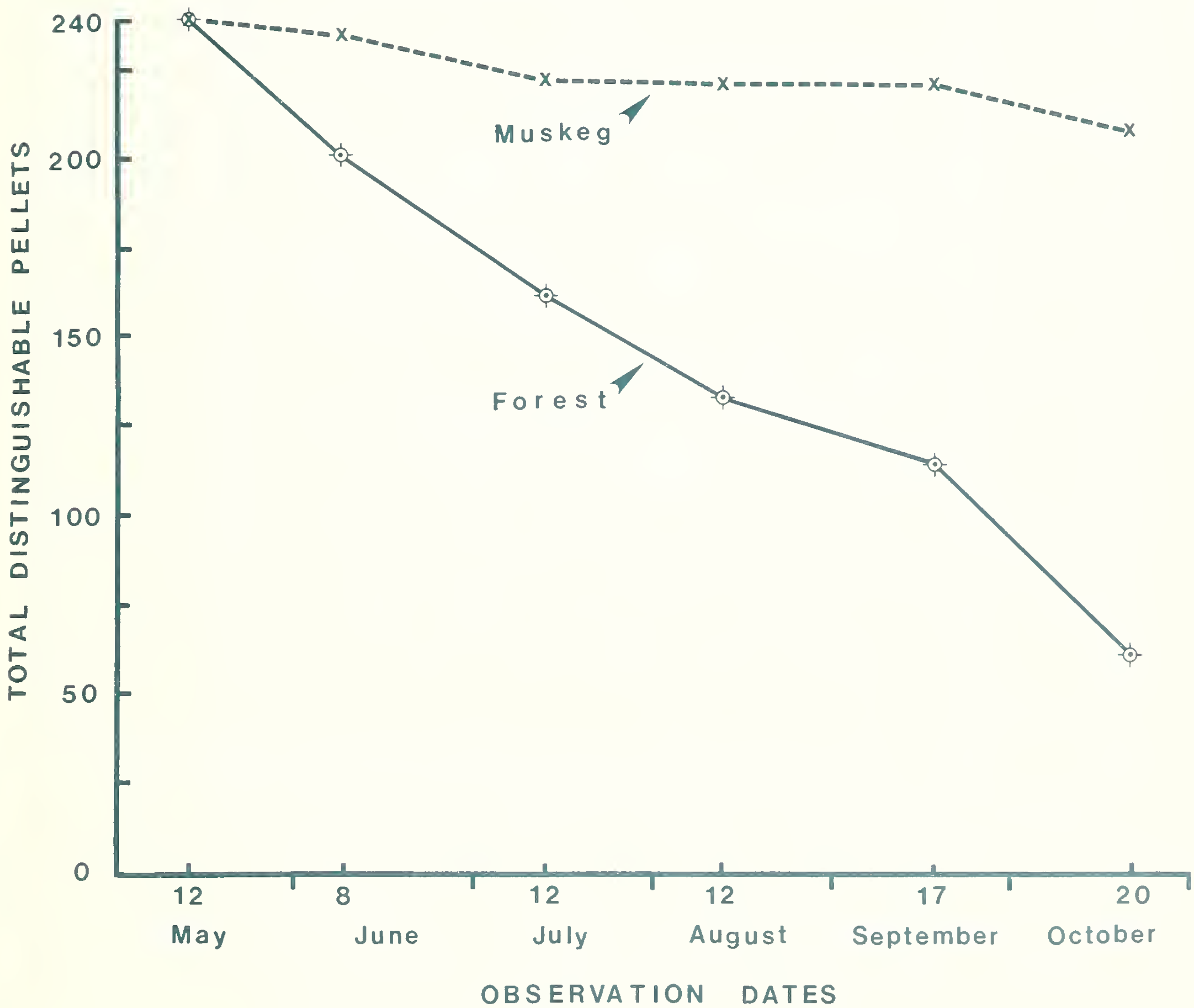
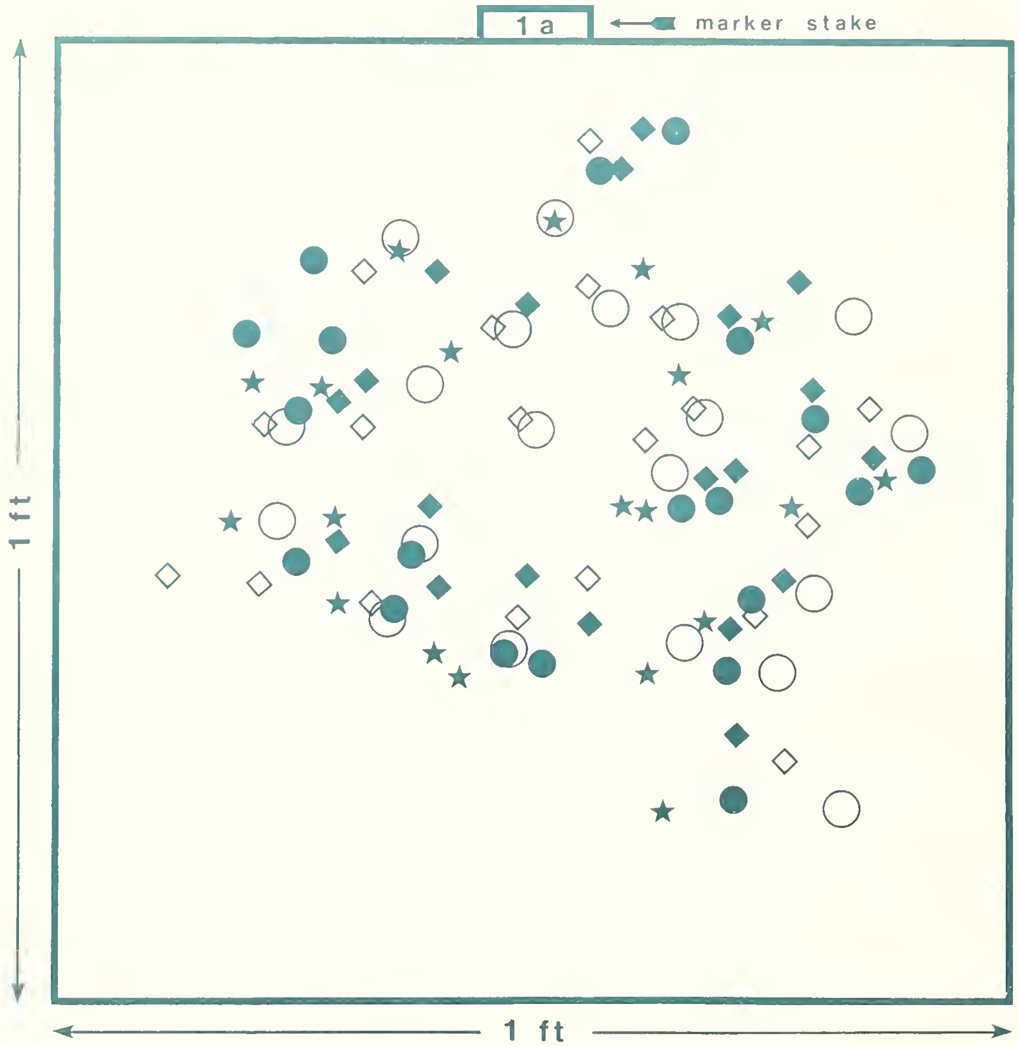
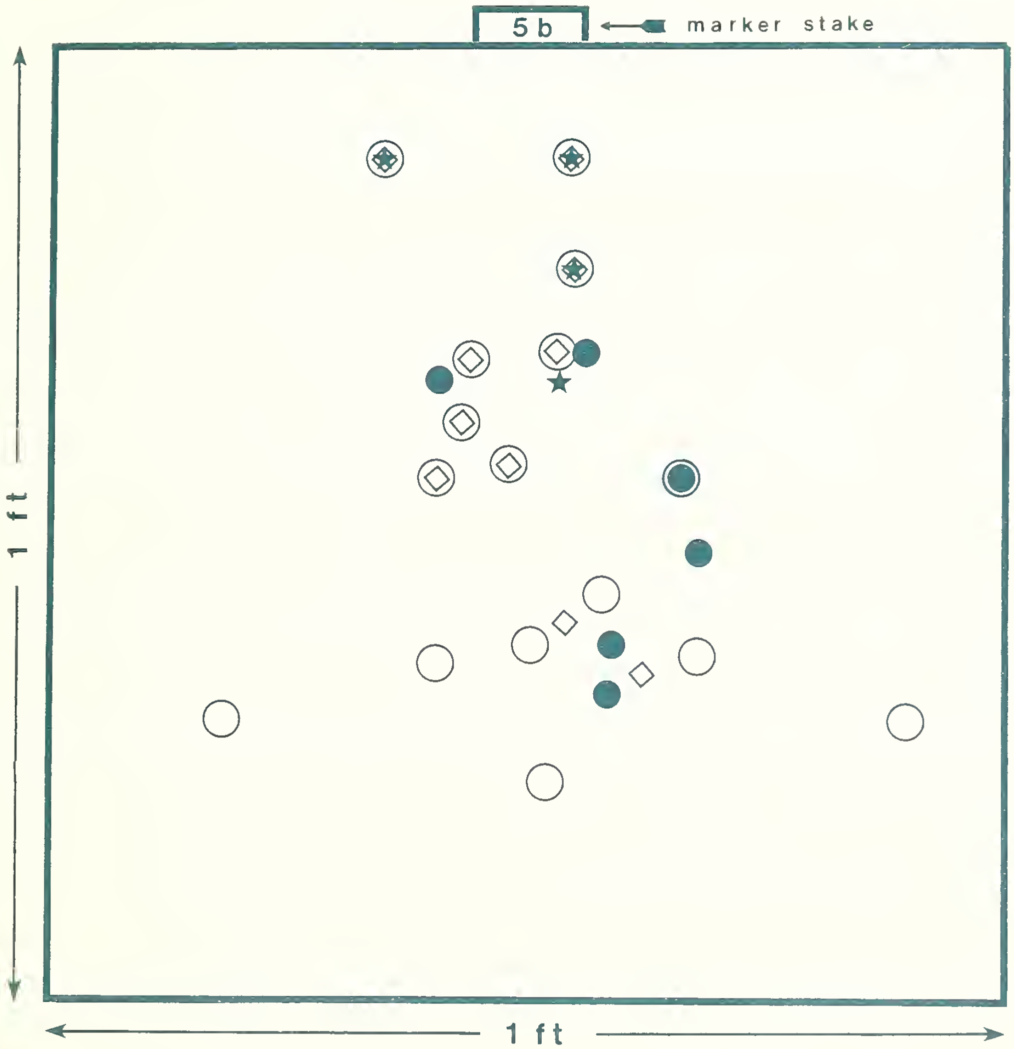


Figure 4. Persistence rate of individual distinguishable pellets.



	visible	pellets
○ May	12	20
○ June	8	20
◇ July	12	20
★ August	12	20
◆ September	17	20
● October	20	20

Figure 5. Distribution of deer pellets on plot la, open muskeg, on successive observation dates.



		visible	pellets			visible	pellets
○	May	12	16	★	August	12	4
○	June	8	16		September	17	none
◇	July	12	10	●	October	20	6

Figure 6. Distribution of deer pellets on plot 5b, forest zone, on successive observation dates.

In addition, research should be expanded on time-relative differences in dispersal rates of recognizable groups between forested and open areas and should include regrowth stands of various ages. With the proportional difference discussed so far, summer counts in the forest would underestimate deer use relative to muskeg or open areas. This could have implication with respect to comparing use in forest and clearcuts.

Development of methods for aging deer pellets, based on characteristics at different time periods, would allow the pellet-count method to be used without clearing pellets from fixed plots. The latter would make it possible to sample larger areas with available time and manpower.

Tongass National Forest Management

The following papers discuss the policy framework within which deer habitat management was expected, at the time of the conference, to be conducted on the Tongass National Forest. At that time, alternative proposals for a long-range Tongass Land Management Plan were being developed. Since then, the Federal administration has converted several areas of the Forest to National Monument status, independently of the TLMP planning process, and excluded them from consideration for normal commodity management. Also, land allocations to the State and to native corporations, under provisions of the Alaska Native Claims Settlement Act, have yet to be resolved by Congress.

While these papers still represent the philosophy of the Forest Service toward integrated resource management, subsequent and future changes in the land base available for such management, date the presentations in some respects.

The paper authored by M.M. Perensovich, Jr. was presented by E.L. Young, wildlife biologist on the Stikine Area, Tongass National Forest. The paper by John Raynor is a digest of his remarks prepared by the editors and revised by Mr. Raynor.

Tongass Wildlife Policies, Goals, and Issues Contained in the Southeast Alaska Area Guide

by

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Introduction

I have been asked to discuss wildlife policies, goals, and issues contained in the U.S. Forest Service's Southeast Alaska Area Guide (SEAAG), with special reference to the management of deer.

The Guide is the first phase in a planning process that provides a foundation and a focus for developing the Tongass Land Management Plan (TLMP). TLMP will then focus on the solution of issues identified in the Guide and identify areas where different land management opportunities will be available.

What is the SEAAG and what does it represent? The task facing the U.S. Forest Service is to manage the public wealth of the Tongass National Forest in a way that recognizes both its wildland uniqueness as well as its economic productivity. The U.S. Forest Service also must be responsive to local, regional, and national needs. The SEAAG identifies issues and establishes a process by which issues can be resolved. The Guide also begins to allocate resources through Land Use Designations (LUDs) or units of land designated for different levels of development. These designations will be translated to specific sites in the TLMP phase.

The Guide contains a section on resource accounts prescribing management direction for 10 resources including soil, water, fish, wildlife, estuary, timber, minerals, recreation, wilderness and cultural resources.

Wildlife Resource Account

The wildlife resource account includes a situation statement and basic assumptions, defines issues and goals and lists specific policies. The situation facing the forest manager relative to the wildlife resource is the challenge of

coordinating forest development with wildlife habitat requirements. This necessary coordination is complicated by the abundance and diversity of wildlife populations. Incomplete information on the impacts of resource development on wildlife often further complicates management decisions.

The implications of land use activities on wildlife populations, including deer, may be more serious over the long run. Also, large scale conversion to younger even-age stands may reduce populations--in direct contrast to management objectives.

Assumptions--The Guide states some basic assumptions upon which to base goals and policies. A list of assumptions relating to deer management includes:

1. Hunting will increase substantially in the next 25 years.

2. Commodity uses and other forest resources will lead to greater impacts on deer habitat.

3. Public pressure will increase to limit or reduce forest development activities where significant adverse impacts affect valuable species including deer.

4. Natural habitat will be lost as a result of permanent developments.

5. Expanded road systems will provide greater access to new areas.

6. Transfer of public lands to private ownership may increase the value of National Forest land for wildlife habitat.

7. Habitat manipulation of protection may receive primary management emphasis.

Goals--The goals identified in the Guide are typical broad statements of the strategy from which objectives are developed. The Guide defines wildlife habitat as the areas of land and water necessary to maintain populations at the "established levels." The primary management goals within and adjacent to wildlife habitat will be:

to protect and enhance wildlife resources and their habitat;

to prevent human-induced wildlife habitat impairment; and,

to maintain the capability of the land and water to produce and sustain desired levels of wildlife populations.

Another stated goal is to develop methods to assess the impacts of forest management on wildlife populations.

Discussion

The goals point out 2 important factors that will need defining before wildlife can be effectively managed. These are 1) describing and identifying types of habitat and their limitations, and 2) the setting of desired levels of deer, and other wildlife, populations which we are interested in maintaining. The policies as listed in the Guide help define these factors and set a baseline, or starting point, to accomplish the goals.

Emphasized throughout the Guide and stated clearly in the policies is the need for coordination between the State and federal agencies. Of particular importance is close coordination with the Alaska Department of Fish and Game in the management of wildlife and its habitat. Cooperation with the State begins with setting desired levels of populations of wildlife species. When these levels are set, effective habitat management, with definitive goals, will become a reality. Conversely--until desired levels of wildlife populations are determined and agreed upon, reasonable management of the habitat is impossible. Desired levels will be determined using factors such as land capability, other resource values, demand, relative abundance, competition with other species, and coordination with other resources or needs.

As part of the land use planning process, the Area Guide outlines a method of determining how wildlife habitat needs will be integrated with the management of other resources. This process involves the use of an interdisciplinary team (IDT) through all levels of land management planning and assures wildlife considerations in all major proposals for land use.

Another factor of wildlife management keyed into the wildlife resource account is the need for land management decisions to be based on sufficient knowledge and data, thus providing a sound basis for professional judgment. A problem identified in the wildlife resource account is the lack of sufficient knowledge and data on which to base these land management decisions.

Often, recommendations are based on limited data and result in conservative measures. As demand for forest products increases, biological input into management decisions will receive close scrutiny. To acquire accurate data on the results of land management impacts, a viable and continuous program of monitoring and assessment of impacts of land use activities on wildlife habitat and populations is necessary.

In addition, several research projects are suggested in the Guide. These include determining the effects of logging practices in old-growth forests on wildlife, initiating and evaluating methods of improving and protecting big game habitat, and determining supply and demand predictions for wildlife.

As a planning tool, and a document to standardize and direct Forest Service Land Management in southeast Alaska, the Southeast Alaska Area Guide is an important first step.

Deer Habitat Inventory for the Tongass Land Management Planning Process

by

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Introduction

This report summarizes portions of the findings of the wildlife habitat inventory completed upon the Tongass National Forest during 1977. It emphasizes information relating to deer which constitutes 1 of 11 categories of wildlife selected for the inventory.

The inventory stemmed from the need for wildlife information in the development of the Tongass Land Management Plan. This Plan, which is a major component of an intensive planning process throughout the National Forest system, responds to direction by Congress, primarily through passage of the Forest and Rangeland Renewable Resources Planning Act of 1974, the National Forest Management Act of 1976, and the Federal Land Policy and Management Act of 1976. The wildlife habitat inventory was the first major combined effort of the Tongass National Forest to assembly information covering a wide spectrum of wildlife.

The Study Area

The study area, encompassing the Tongass National Forest, is located in southeast Alaska and is divided into 3 administrative areas or forests: Chatham Area - 7,489,149 acres, Stikine Area - 3,161,792 acres, and Ketchikan Area - 5,265,230 acres (net land acreage). A total of nearly 10,000 miles of shoreline is contained in these areas (see fig. 1).

Southeast Alaska is characterized by a cold, very moist rain forest, most of which is old-growth western hemlock and Sitka spruce. Western redcedar and Alaska cedar is restricted primarily to the southern half of the area, south of Frederick Sound. Muskeg or bog plant communities, dominated by sphagnum mosses and sedges, are found interspersed throughout forest openings. These openings also support a variety

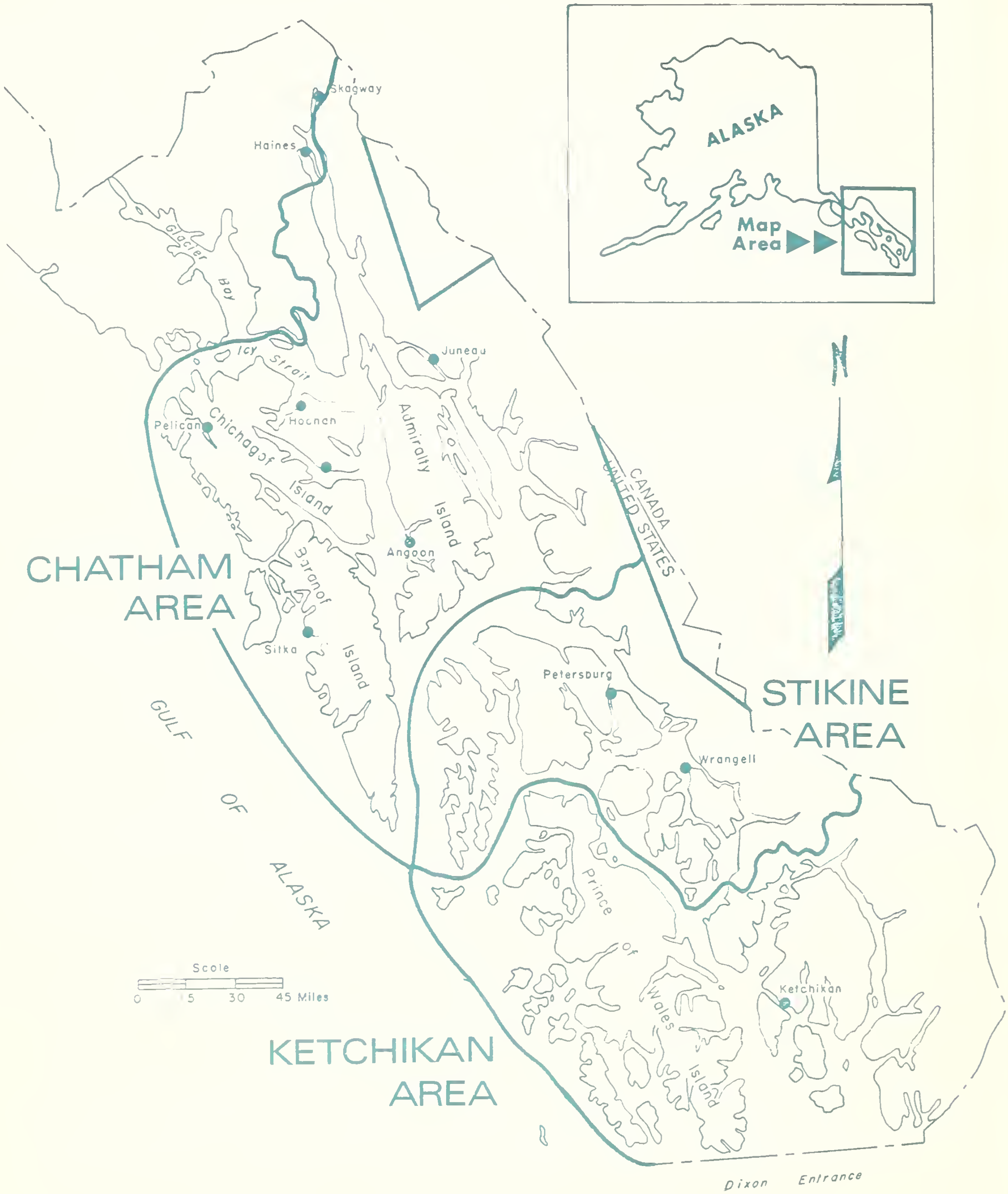

Figure 1--The 3 administrative areas of Tongass National Forest. Chatham includes an area near Yakutat indicated by the circle in the inset.

of low shrubs, forbs and sparse stands of hemlock and lodgepole pine. Grass-sedge meadows, usually situated along the coast, and alpine tundra make up the remaining major types of habitat. These biotic communities comprise important habitat for deer as well as a wide variety of other wildlife.

Methods

A core team of 8 biologists was formed to conduct the inventory. This team included biologists from the U.S. Forest Service, U.S. Fish and Wildlife Service, and Alaska Department of Fish and Game. Forest Service biologists were given primary responsibility for completing work on their respective areas. Additional biologists, acting in an advisory capacity, provided information throughout the inventory process, including participation in the development of a study plan. Establishment of these guidelines, which set forth standards, methods, and schedules, was an important initial phase of the inventory.

Included in the study plan are rating standards for each of the 11 categories of wildlife. The standards or ratings assigned to deer were as follows:

0 -- absent

1 -- present; traditionally low density areas

2 -- intermediate winter range (including forest habitat extending between low elevation winter ranges and sub-alpine zones). Recommended retention factor: 50 percent, comprised of old-growth, commercial forest land.

3 -- lowland winter range (including beach fringe to 500-foot elevation or approximately 1 mile inland from shoreline on level topography). Recommended retention factor: 90 percent, comprised of old-growth, commercial forest land.

Timber retention percentages, coupled with each of the species habitat ratings, were needed as a basis for calculating the amount or volume of existing old-growth commercial forest land that should be retained for deer habitat. This information will serve as a means for adjusting the annual allowable harvest figures for timber management. Retention factors express the minimum percentages of habitat needed to maintain existing population levels for deer as well as other wildlife. These factors allow for growth and expansion of populations currently at low levels and include provision for a cautionary approach to management of those species, for which information in incomplete, concerning the impacts of land use activities on their habitat.

Wildlife-related use patterns (hunting, trapping, wildlife-viewing, etc.) were rated either by species or by groups of species and uses, depending upon availability of information for each administrative area.

The initial phase of the inventory involved assembling and reviewing all available information in the form of in-service reports, planning maps, multiple-use overlays and a host of related material, including data from other agencies. Habitat and species range maps, contained in the Alaska Department of Fish and Game's Wildlife and Habitat Blue Book, with supplemental overlays, provided a valuable source of information. Information obtained from field surveys (although done on a limited scale) and ongoing interdisciplinary team surveys helped considerably in identifying important wildlife habitat. Personal interviews with key people in towns and outlying

villages provided useful information especially with regard to human use areas. Finally, professional judgment shaped necessary assumptions for those areas where information was lacking.

Information was mapped on U.S. Geological Survey quads, 1 inch = 1 mile (scale 1:63360), according to the format contained in the study plan. Overlays were used extensively throughout the mapping process. In most cases, only habitat in categories 2 and 3 (which contain ratings combined with assigned timber retention percentages) were mapped. Habitat ratings for individual species were then determined for each value comparison unit (VCU);1/ these ratings were recorded on forms developed for the inventory to accompany each completed set of quads. In some cases a subjective approach to rating species habitat was necessary; under such circumstances factors such as amount, category, and location of habitat involved and known status of populations were considered in the rating process.

Ratings for each species were totalled for each VCU. The final ratings, which consider all categories of wildlife, were obtained by determining the range of the lowest and highest scores for all VCUs and dividing the results into 5 appropriate rankings of low to high habitat quality. This rating scheme considered all wildlife of equal value, assigning no weight factors to any individual species or group. Thus, VCUs having greater species diversity, or number of wildlife groups represented, had a potentially higher rank than those with fewer species.

Results

To understand the reported results of the inventory, it is necessary to distinguish clearly between data which represent percentages of VCUs (table 1) and data which represent percentages of total acreage (table 2). To illustrate this problem, consider the ratings for category 2 habitat (intermediate winter range). In terms of total VCUs, the Ketchikan Area has the highest percentages of category 2 habitat (39 percent), followed by the Stikine Area (20 percent) and then the Chatham Area (12 percent). Because the total number and total size of VCUs within each Area differ, however, these percentages do not reflect the relative importance of each Area in contributing total acreage to intermediate winter range. Thus, 12 percent of the VCUs and 2,416,738 acres in the Chatham Area are in category 2, while 39 percent of the VCUs and 2,486,616 acres in the Ketchikan Area are in category 2. The Stikine Area has 20 percent of its VCUs and 781,662 acres in category 2.

Geographic location also influences the percentage of VCUs in each habitat category in the administrative areas. Because of more severe winter conditions, for example, the mainland characteristically supports a much lower density of deer than do the islands. Forty-two percent of the Chatham, 37 percent of the Stikine, and 29 percent of the Ketchikan VCUs are on the mainland. Correspondingly, Chatham has the highest percentage of VCUs (22 percent) rated zero, or absent, for deer. Likewise, because the Chatham has the greatest number of island VCUs, it also has the highest percentage (49 percent) of category 3 habitat.

1/ A distinct geographic area generally encompassing a drainage basin with one or more large stream systems bounded by easily recognizable watershed divides. These units provide a common set of areas for resource inventories and resource value interpretations.

Table 1. Distribution of VCUs by deer habitat rating categories in the administrative areas of Tongass National Forest

Category[1/]	Chatham	Stikine	Ketchikan	Tongass total
	----------------number of VCUs----------------			
0	86	0	51	137
1	66	47	38	151
2	45	27	134	206
3	193	62	118	373
Total	390	136	341	867
	----------------percent of VCUs----------------			
0	22	0	15	16
1	17	34	11	17
2	12	20	39	24
3	49	46	35	43

1/ 0 = absent, 1 = low, 2 = moderate, 3 = high.

Table 2. Total and commercial forest land (CFL) acreage classified as deer habitat categories 2 and 3 in the administrative areas of Tongass National Forest. From printout summary of landtype data sheets, Landtype/Timber Task Force.

Area	Category[1/]	Total deer habitat		Deer habitat on CFL	
		Acres	Percent	Acres	Percent
Chatham	2	2,416,738	32.27	1,228,996	61.08
	3	632,737	8.45	403,847	20.07
Stikine	2	781,662	24.72	778,282	65.85
	3	140,512	4.44	139,793	11.83
Ketchikan	2	2,486,616	47.23	1,523,193	69.65
	3	319,129	6.06	246,992	11.29
Tongass Forest total	2	5,653,908	35.52	3,536,695	65.61
	3	1,085,816	6.82	789,173	14.64

1/ Category 2--intermediate winter range, retention factor 50 percent;
Category 3--critical winter range, retention factor 90 percent.

Table 2 summarizes interpolations made by the Landtype/Timber Inventory Task Force from wildlife habitat mapped by the Wildlife Task Force. Again, location of area VCUs is a factor in determining amount of commercial forest land. The number of acres of commercial forest land within each administrative area is influenced by latitude. Volume of timber per acre is generally highest in the southernmost latitudes (Ketchikan Area), with volumes gradually decreasing to the north. This factor is reflected by the percentage of each administrative area in commercial forest land: Ketchikan 41 percent, Stikine 37 percent, and Chatham 27 percent. Thus, the Ketchikan Area has the largest acreage in category 2, intermediate winter range--1,523,000 acres comprising nearly 70 percent of the commercial forest land. On the other hand, Chatham leads in category 3, lowland winter range, with 404,000 acres, or 20 percent of the CFL.

The Forest total for category 2 and category 3 winter range provides an interesting insight into the magnitude of deer habitat for all areas combined. The total intermediate winter range amounts to 5,654,000 acres or roughly 36 percent of the total forest; this includes 3,537,000 acres, or 65 percent, of the total forest CFL. For category 3, lowland winter range, the total acreage is 1,086,000, or 7 percent of the total forest area, including 789,000 acres and 15 percent of the CFL.

Conclusion

It should be recognized that an inventory of this magnitude possesses some limitations--primarily involving time constraints, the large size of area, and frequent demand for professional judgment in lieu of detailed information. Nevertheless, information obtained concerning deer and habitat should provide a suitable information base for resource allocations to be made at the level of planning for which this inventory was conducted.

Timber Harvest Methods and Objectives: a digest of remarks compiled by the editors

by

John Raynor
USDA Forest Service
Alaska Region, Juneau

Timber harvesting began in southeast Alaska during the Russian occupation and continued at low levels in the early years after the American purchase. By the period 1950-1960, about 15-60 million board feet (MMbf) were being removed from the Tongass National Forest annually. In 1951, a contract was signed with Ketchikan Pulp Company (now Louisiana Pacific - Ketchikan Division; LPK) to provide 8.25 billion board feet over 50 years. In 1956, the Alaska Lumber and Pulp Company (ALP) was awarded rights to 5.25 billion board feet over 50 years. A third contract, now held by Alaska Wood Products Company, affiliated with ALP, provides 693 million board feet over 25 years.

These harvests were to come from a timber-land base of about 4.9 million acres and an annual allowable cut (AAC) of 1.2 billion board feet. Land withdrawals from the Tongass commercial timber base resulting from the Alaska Native Land Claims Settlement Act, State land selections, and the final Tongass Land Management Plan are expected to reduce the AAC to about 500 million board feet.

Forest Service timber managers will be expected to meet the contractual obligations from the remaining harvestable timber on the Tongass. While the Forest Service classifies commercial timber land as that with 8,000 or more thousand board feet (scaled volume) per acre, the average volume on areas cut in recent years has been over 25,000 thousand board feet per acre.

On National Forest lands, some restrictions will be imposed to protect other resources. These regulations will not apply to State, Native, and other private lands.

Striking a Balance Between Timber Production and Maintaining Deer Habitat

by

Rai Behnert
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USDA Forest Service, Juneau

Introduction

The brief analysis that follows is based upon a review of resource information supplied by the Wildlife and the Landtype/Timber task forces, both of which were formed to support the Tongass National Forest Land Management Planning effort. The analysis presents some preliminary quantifiable parameters that can be considered in the analysis of the deer habitat/timber management issue. Utilization of such available information can help define the bounds of what may be at stake.

Assumptions

1. Between 5.5 and 7.0 million acres of the Tongass National Forest will be allocated to land use designations I (wilderness) and II (roadless area management). [Source: Southeast Alaska Area Guide, Part B.]

2. A minimum of 1.0 million acres of the total 5.5 million acres of commercial forest land would be included in the lands that will be allocated to land use designations (LUDs) I and II. Since timber harvest is not permitted on lands allocated to these LUDs, no foreseeable effects on deer habitat are anticipated.

3. A maximum of 4.5 million acres of commercial forest land would be available for timber harvest purposes on the lands that are allocated to LUDs III and IV over the next 135 years (assumed length of rotation period). This would permit a maximum of 33,000 acres, or .7 of 1 percent of the available commercial forest land, to be harvested annually.

4. Even if 4.5 million acres of commercial forest land are allocated to LUDs III and IV, it is unlikely that all of these acres would be harvested over a rotation. The

land management policies stated in the Southeast Alaska Area Guide would have to be violated to do so. Thus, harvest of the 4.5 million commercial forest land acres can only be considered a theoretical limit that does not include necessary reductions to manage for other than timber values.

Givens

1. An estimated 15 percent (800,000 acres) of the commercial forest land is considered critical deer winter range. [Source: Wildlife task force input to the Landtype/Timber inventory.]

2. Sixty-five percent (3.5 million acres) of the commercial forest land is considered intermediate deer winter range. [Source: Wildlife task force input to the Landtype/Timber inventory.]

3. A total of 4.3 million acres, or 78 percent, of the total commercial forest land could be considered as important to deer. This means that roughly 3 out of every 4 acres of commercial forest land on the Tongass, or 25,000 of the 33,000 acres that could theoretically be affected annually, could affect deer to some degree.

4. An average of roughly 20,000 acres of commercial forest land have been harvested annually since 1970.

Whole Forest Effects Analysis

Based on the above assumptions and givens, about .7 of 1 percent of the important deer habitat could be affected annually if timber yields are maximized without consideration of other resource values. Since other resource values will be considered in the management of the forest and since it is unlikely that timber yields could be maximized due to economic factors alone, much less than the above amount of habitat is likely to be affected. I would estimate that between .3 and .5 of 1 percent (13,500 to 22,500 acres) will be affected annually. Over a full rotation, this could cumulate to between 20 and 50 percent of the important deer habitat.

Thus, while the magnitude of the effect on deer habitat may be fairly small in a given year, the cumulative effect over many years could be substantial. If the upper end of the range, or half the habitat, is affected over the long run, a fairly large trade-off of deer habitat to satisfy demands for timber may be implied. If the lower end, or about 20 percent, is affected, then the implied trade-off would be much lower.

How much timber is harvested annually, where timber harvesting actually takes place, how well the interdisciplinary teams design timber sales in relation to the habitat needs of deer, how rapidly our knowledge about deer/logging relationships is expanded and how public demands for timber and deer are expressed will all bear heavily on the actual balance that will be achieved between timber production and the maintenance of deer habitat. I am optimistic that a reasonable balance can be found.

> [*Editors' Note:* Since this conference on Sitka black-tailed deer was held, the USDA Forest Service released the final environmental statement for the "Tongass Land Management Plan." Copies were distributed to major libraries. Additional copies may still be available from the USDA Forest Service, P.O. Box 1628, Juneau, Alaska, U.S.A. 99802.]

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